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OPINION

Admiral Arun Prakash (Retd) says....

Pragmatism, not jingoism will help India deal with China

(Image: Belt and Road News)

Well before it recklessly triggered World War II, Germany had provided enough evidence of its hegemonic intent and disdain for international conventions. In September 1938, British Prime Minister Neville Chamberlain announced on return from the Munich conference with Hitler: "I believe it is peace for our time." His gullibility was shown up a year later when Hitler, ordering the invasion of Poland, remarked: "Our enemies are little worms. I saw them at Munich."

India's "Munich moment" came in 1962 with the egregious misreading of China's intent by a naive political leadership, leading to a humiliating military defeat in the Sino-Indian war. On 20 October 1962, India's 7th Infantry Brigade was overrun by the 11th Division of the People's Liberation Army at Namka Chu. The Indian soldiers fought gallantly, often to the last man and the last bullet, but in vain. Similar actions took place elsewhere in NEFA (now Arunachal) and Ladakh. The rout lasted all the way up to 20 November when the Chinese declared a unilateral ceasefire and withdrew 20 km behind the Line of Actual Control (LAC).

The LAC had been described by PM Zhou Enlai in 1959 as conforming to "the so-called McMahon Line in the east, and the line up to which each side exercises actual control in the west." India did not agree with this definition but its failure to diplomatically contest and militarily defend this line gave China physical control of 38,000 sq km of the Aksai Chin plateau in 1962. Subsequently, China has claimed 84,000 sq km of Arunachal Pradesh as part of "Southern Tibet".

There is probably no precedent where two belligerents after fighting a "border war" have left their disputed boundary undetermined and unmarked for 60 long years. Indian politicians and diplomats used to derive satisfaction from having de-linked the border issue from the rest of the Sino-Indian relationship and rejoiced as bilateral trade — though adversely balanced — zoomed past the $100-billion mark. But to a layman, it appeared that by neglecting to pursue a negotiated demarcation of the LAC, and by glossing over repeated territorial incursions as "differences of perception," our security elite had played into China's hands.

The government's stand that "no Indian territory has been occupied by China", seen in the light of the May 2020 sanguinary clash in Galwan, and the 22-month Sino-Indian military stand-off, has confused the citizens and raised many concerns. In Ladakh, if the Chinese have indeed not encroached on our territory, then why are our troops unable to access previously established "patrolling points" and what exactly are the "friction points" that find frequent mention in communiqués? In Arunachal, are the freshly-built Chinese enclaves and the towns re-named by them located in Indian territory? Finally, what has been the outcome of 22 meetings of the "special representatives" and why have military commanders failed to achieve "disengagement", leave alone "de-escalation" in 14 meetings?

These conundrums indicate that from Jawaharlal Nehru's desperate optimism, encapsulated in the "Hindi-Chini bhai-bhai" nostrum, to PM Modi's sustained engagement with Xi Jinping, Beijing has deviously managed to camouflage the true motivation behind its actions as well as its long-term intentions vis-à-vis India. New Delhi, on its part, has failed to evolve a strategy to counter China's designs or even issue a White Paper to explain the dimensions of this challenge to Parliament and the public.

China, having amply demonstrated its penchant for "salami-slicing" territory, as well as its disdain for international law, leaves India with little room for complacency or for vainly hoping that so-called "legacy issues" will resolve themselves with time. It is, therefore, vital to deconstruct China's elaborate charade and to halt the covert but steady bleeding of Indian territory.

While jingoism has its place in politics, we must be realistic enough to understand that neither conquest nor re-conquest of territory is possible in a nuclearised South

(File photo: AFP)

Asia. India's Parliament and government should now accord utmost priority to establishing settled, viable and peaceful international boundaries all around. Only then will India be able to focus on nation-building and socio-economic development without interruption. A few pragmatic options offer themselves for resolving the Sino-Indian imbroglio.

First, India could exhume and revive the offer reportedly made by PM Zhou in 1960. Seeking strategic depth for Highway 219 that links Xinjiang with Tibet across Aksai Chin, Zhou had suggested negotiating a "quid pro quo" wherein China would recognise the McMahon Line in exchange for India making certain adjustments in the west. This would call for considerable political boldness and diplomatic adroitness.

A second option would be for India to bring sustained pressure to bear on China on the diplomatic, trade and psychological fronts and await results. At the same time, Indian forces must remain poised for swift direct action; seizing unoccupied territory and holding on to it as a bargaining chip. The surprise capture of tactical heights on the Kailash Range by our Special Forces brought severe psychological pressure on Beijing and must serve as a template. While skirmishes and physical confrontations may take place, it is considered most unlikely — for several reasons — that China would take on India in a major or even a limited conflict.

A third option lies in the maritime domain where opportunities exist, both for power-balancing via partnerships, as well as direct naval action. China's economy and industry are overwhelmingly dependent on uninterrupted seaborne trade and energy. Thus, China's Indian Ocean sea lanes constitute a "jugular vein" that India could threaten via trade warfare. In this context, the Andaman & Nicobar Islands, suitably fortified and militarised, could become maritime bastions, dominating the Malacca Straits. Far more strategic advantage could accrue if India were to shed its political coyness and offer Port Blair as a logistic "watering hole" to selected friendly navies.

The last option would, obviously, be to maintain the status quo — with 50,000-60,000 troops deployed at high altitudes — and engage in sustained military/diplomatic parleys hoping for useful outcomes — with an unpredictable Chinese threat hanging over our heads like a sword of Damocles.


Tanks on the banks of Pangong Tso lake region, in Ladakh along the India-China border (Indian Army via AP)


Video frame grab taken from footage recorded in mid-June 2020, showing Chinese (foreground) and Indian soldiers (R, background) during an altercation in the Galwan Valley. Image: AFP/China Central Television (CCTV) via Getty Images.

Admiral Arun Prakash (Retd) says...

125th anniversary of Subhas Chandra Bose: An inclusivist and a patriot

The Republic Day celebrations will now begin from 23 January marking the 125th birth anniversary of Netaji Subhas Chandra Bose. A charismatic leader, with a steely resolve, the military icon's grand strategic vision included not just the attainment of freedom, but building a strong and secular India.

There is growing recognition of the probability that the British may have been able to evolve suitable responses to the tactics of India's Gandhian freedom fighters, like 'non-violence' and 'satyagraha', and hold on to India for a couple of decades beyond 1947. What really shook them was the raising, by Subhas Chandra Bose, of the Indian Legion in Germany from prisoners of war (PoWs) in early 1942. This was followed by Bose assuming command of the Azad Hind Fauj or the Indian National Army (INA) in Singapore in 1943. Realisation dawned on the British that every Indian soldier who loyally served the crown was also a patriot at heart; and therefore, sympathetic to the cause of freedom.

Disciplined militaries never dwell on mutinies, desertions and other breaches of discipline, regardless of the cause. Consequently, the attitude of Independent India's armed forces towards the INA, and its Commander-in-Chief (C-in-C), Subhas Chandra Bose, has remained guarded and ambivalent. Paradoxically, however, the ethos and spirit of the Indian Legion and INA have permeated into the Indian military. English words of command used in the British Indian army were translated by German military instructors into Roman-Hindustani equivalents for use by the Indian Legion. Many of these commands were adopted by the post-Independence Indian Army. The Indian Legion/INA greeting, 'Jai Hind', was first adopted by the Army, and is now universal in all three services. The INA marching song, 'Kadam-Kadam Barhaye Ja' has become the Indian Army's marching song.

Bose's German biographer, Rudolf Hartog, has written, "One tends to forget that the Indian Legion was not only an army set up to fight the British, but that it personified Bose's vision of the future India in which neither religion, nor caste, neither culture nor language… would divide the country… Hindus, Muslims, Sikhs and Christians served alongside." Regrettably, fate intervened to deny Bose his cherished vision, and today a capricious nation needs to be reminded that this bold and daring patriot, in exile, shook the British Empire to its roots and, accelerated its demise in India.

The expatriate armies led by Bose in Germany and Singapore, his inspiring radio broadcasts from Berlin, Rome and Tokyo and his intense diplomatic exertions to muster support for India's freedom were factors that not only motivated and galvanised the freedom movement in India, but also struck fear into British hearts. The 1946 mutiny in the Royal Indian Navy was to add momentum to the Independence movement. So much so, that General Wavell, the British Commander-in-Chief, ruefully remarked in a secret report: "It is no use shutting one's eye to the fact that any Indian soldier worth his salt is a Nationalist…"

Bose's career as a politician of national stature came to a premature end as his differences with Gandhiji led him to resign from the presidency of the Congress party. However, once he left India and formed a government-in-exile, he donned the political mantle of a notional head of state as well as the military mantle of a Commander-in-Chief. From then onwards, Bose needs to be viewed in a different light altogether; as a statesman of international standing and an outstanding leader who showed moral courage, sagacious vision and resolute action. He is fully deserving of the appellation 'Netaji'— not in its current unsavoury political connotation, but as a true leader, and his 125th birth anniversary is an apt moment for a reappraisal of Bose's national standing.

In the mid-1940s, Bose was arrested on charges of sedition, and while in jail, pondered over the developments in Europe. As a fierce nationalist, and a pragmatist, Bose sensed that a weak and enslaved India, pitted against ruthless British imperialism, was unlikely to win freedom through non-violent means. Convinced of an Axis victory, he reasoned that it was worth 'supping with the devil' and seeking help of the Fascists if it helped his country's fight against colonialism. Should it, subsequently, come to a confrontation against the Japanese or Germans, he visualised the two-million soldiers of the British Indian army as his assets. But first, he had to establish contact with the Axis regimes.

On the night of 17 January 1941, while under house arrest, a disguised Bose escaped from his Calcutta home, and travelling by train, bus and on foot reached Kabul, 10 days later. Masquerading as an Italian businessman, he left Kabul with two German escorts for Moscow, whence he flew to Berlin, arriving in the German capital on 28 March 1941.

Bose was welcomed in Germany, and provided with a residence, car and office, by the Foreign Minister, von Ribbentrop. Once firmly established in Berlin, Bose launched a multi-pronged campaign in his resolute pursuit of the cause of Indian freedom. He established a Free India Centre, with branches in Berlin and Rome, as well as the Azad Hind Radio from where regular broadcasts were beamed to India in seven Indian and other languages.

One of Netaji's most outstanding achievements was to obtain German consent to raise an Indian Legion and then, through the force of his personality and convictions, to persuade British Indian army PoWs, captured by the Germans in North Africa, to join the Legion. Trained, equipped and armed as a regular unit of the Wehrmacht (German army), the outfit was designated as Infanterie Regiment (Indien) 950. The jawans who volunteered to serve in the Legion faced an acute moral dilemma, but they, stoically, swore an oath of loyalty to the German Fuehrer as well as to Netaji, and it was agreed that they would be deployed only against British forces, while awaiting the opportunity to fight for freedom on their own soil.

It was more than a year after his arrival in Berlin that Hitler finally agreed to receive

Till the grand statue of Netaji Bose is completed, a hologram statue of his would be present at the same place at New Delhi

Netaji in a private audience. Declining Netaji's request for a formal declaration of support for "free India" as premature, Hitler advised him to work with the Japanese so that he could be much closer to his homeland. Netaji asked for a German aircraft to take him to Tokyo, but Hitler considered it too risky, and offered him a submarine, instead.

Netaji and his adjutant, Abid Husain, embarked on the German submarine U-180 in Kiel, and after an epic 90-day voyage, involving a high-seas transfer to a Japanese submarine, arrived in Tokyo in May 1943. Netaji's meeting with the Japanese Prime Minister, General Tojo, was the culmination of his single-handed campaign to garner support for India's freedom struggle. He had now received assurances of support from all three Axis leaders: Hitler, Mussolini and Tojo, and could dream of liberating his motherland from the British at the head of an Indian army of liberation.

Having delivered a devastating air attack on Pearl Harbor, the Japanese forces swept across SE Asia to reach Malaya by March 1942. The British forces were caught by surprise and panicked; capitulating or fleeing into the countryside. At the fall of Singapore, a large number of Indian PoWs, feeling betrayed by their British officers, were persuaded by their Japanese captors to join a 'volunteer force', designated as the Indian National Army. Captain Mohan Singh was chosen by the Japanese as its first head, to be followed by Col Bhosale. However, it soon became apparent that this force was in need of a leader with a political vision; and Netaji was to be the man whose stature, personality and outlook made him an ideal C-in-C.

On October 21,1943, following a public declaration of solidarity by General Tojo, Netaji inaugurated the Arzi Hukumat-e-Azad Hind or Provisional Government of Free India, in Singapore, with Netaji as the head of state. Recognition was accorded, to the Provisional Government by Japan, Burma, Croatia, Germany, the Philippines, Italy, and Siam, and Netaji formally declared war on Britain and USA.

Having assumed personal command of the INA, Netaji was seen often at military functions in immaculate uniform, and became a powerful focus of loyalty and fighting spirit for the INA. The planned invasion of India, with Kohima and Imphal as its initial objectives, commenced in February 1944 through the Arakan Hills. Fighting alongside the Japanese 15th Army was the INA's Subhas Brigade, accompanied by psychological warfare groups. Netaji gave the Indian troops their stirring war cry: "Chalo Dilli".

Meeting stiff Allied resistance, the offensive, however, soon ran out of steam and, by early 1945, the Japanese were in full retreat. Dogged by the monsoons and disease, and denied full Japanese support, by May of that year, the short but eventful history of the INA came to an end when this rebel army laid down arms in Burma.

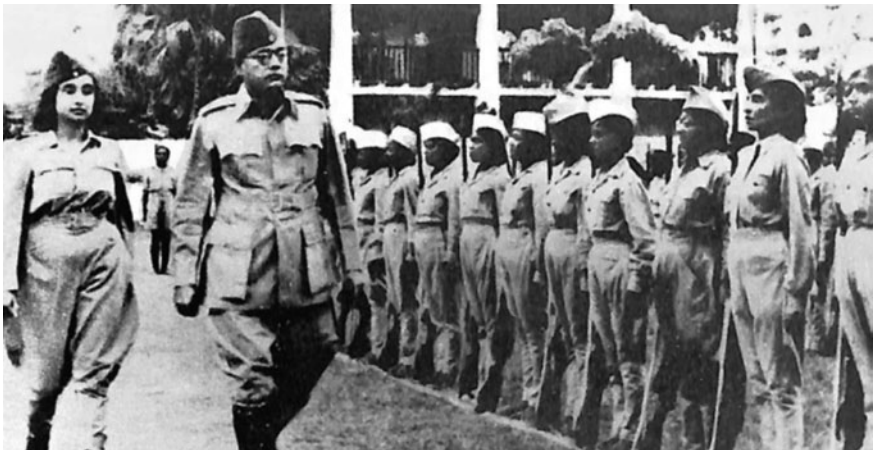
With the fall of Japan looking imminent, Netaji withdrew with his cabinet to Bangkok, where after much deliberation it was decided that the Provisional Government could only be sustained if support for India's freedom was forthcoming from Russian leaders. Russia, having declared war on Japan, was marching into Manchuria and Netaji decided that the city of Darien would be a good place for him to establish contact with the Russians.

Two seats were found for Netaji and his aide, Habibur Rehman, on a Japanese Mitsubishi K-21 bomber which would drop them in Darien, after refuelling halts in Bangkok, Saigon, Da Nang, and Taipei. On the evening of 18 August 1945, just after take-off from Taipei, the heavily loaded bomber crashed and caught fire. Netaji suffered serious burns and died that night in a Japanese military hospital, with Habibur Rehman present at his deathbed. He was cremated in Taipei on 20 August 1945.

As far as the British Indian army was concerned, all the INA personnel had worn the King's uniform and were considered 'traitors' or 'Japanese Inspired Fifth Columnists'. Three INA officers, Shah Nawaz, Sehgal and Dhillon, charged with "waging war against the King", were brought to trial by court martial and found guilty. The British showed good sense by suspending the sentences awarded, and stopping further trials.

As for Bose himself, in terms of stature and moral courage, I would rank him with another contemporary national hero, Charles de Gaulle; who also led France's liberation struggle as an exile. The difference is that while de Gaulle made a triumphant return to a free France, Bose unfortunately perished on foreign soil with his dream unrealised. A grateful France elevated de Gaulle to the highest office, but all that we have done for Bose is to institute endless enquiry commissions into his death.

Netaji Subhas Bose was a charismatic leader of steely resolve. Exiled from his homeland, and a fugitive from the mighty British Empire, with no resources available to him except his own patriotism, audacity and enterprise, Bose believed that freedom would not be given by the oppressor, but had to be taken by force. His grand strategic vision for his motherland was limited not just to attainment of freedom, but to building a strong and secular India and ensuring its rightful place in the world order. An honourable and patriotic Indian, Netaji Subhas had sworn no oath of loyalty to the King-Emperor and therefore, he broke none. We can, with full justification, hold him up, today, as an Indian 'military icon'.



Subhas Chandra Bose, with Captain (Dr) Lakshmi Sahgal, inspecting the guard of honour presented by the Rani of Jhansi Regiment during the opening of the Rani of Jhansi camp at Waterloo Street, Singapore, on 22 October 1943. Courtesy of Netaji Research Bureau.

Work on AMCA begins

HAL in association with ADA has started manufacturing activities of Advanced Medium Combat Aircraft (AMCA). This was revealed on 9 March 2022.

Government plans on AMCA

"Process for obtaining Cabinet Committee on Security's (CCS) approval for design and prototype development of Advanced Medium Combat Aircraft (AMCA) has been initiated. 5th Generation fighter aircraft, due to very special features, are costlier than 4th Generation fighter aircraft. Since AMCA is an indigenous 5th Generation aircraft, it is less costlier than similar aircraft available outside". This information was given by Raksha Rajya Mantri Ajay Bhatt in a written reply to Shanta Chhetri in Rajya Sabha on 14 March 2022.

HAL and Safran's HE-MRO

The ground-breaking ceremony for a new facility of Helicopter Engines MRO Pvt Limited (HE-MRO), a JV of HAL and Safran was held on 14 March 2022 at Sattari (Goa). HAL and Safran signed a strategic MoU during the ceremony. The 1,000 sqm training and office facility and a 3,800 sqm international class shop facility will provide MRO services for Safran TM333 and HAL Shakti engines installed on HAL-built helicopters to increase the operational readiness of the Indian Armed Forces. Shakti is installed on HAL's ALH/Dhruv variants including Rudra and has also been selected to power the HAL-designed Light Combat Helicopter (LCH). The Ardiden 1U variant powers the new Light Utility Helicopter (LUH), a three-ton single-engine aircraft. The engine was certified by DGCA (India) on 26 July 2021 for civil applications.

Historic visit of Commander Royal Saudi Land Forces to India

In a historic and landmark visit, the Commander of the Royal Saudi Land Forces, Lieutenant General Fahd Bin Abdullah Mohammed Al-Mutair, arrived in India on 14 February 2022. This is the first ever visit by a serving Royal Saudi Land Forces Commander to India and marks a deepening bilateral defence cooperation between the two countries. General MM Naravane had visited Saudi Arabia in December 2020 in a historic visit which marked the first time that an Indian Army Chief had visited Saudi Arabia. The aim of the visit is to bolster bilateral defence cooperation between the two countries.

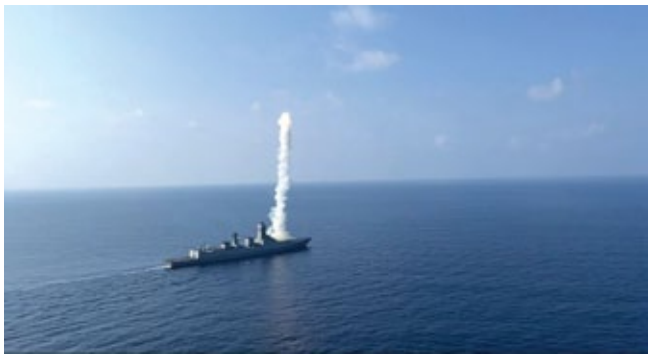
Indian Navy expands fleet with delivery of 12th P-8I

Boeing delivered the 12th P-8I maritime patrol aircraft to India, on 23 February 2022. This is the fourth of four additional aircraft delivered under the options contract signed by the Ministry of Defence in 2016. The P-8I is an integral part of the Indian Navy's fleet and has surpassed 35,000 flight hours since it was inducted in 2013. The aircraft, with its 'exceptional maritime surveillance and reconnaissance capabilities, versatility and operational readiness, has proven to be an important asset to the Navy'. The Indian Navy was the first international customer for the P-8 and today the P-8 is also operated by the US Navy, the Royal Australian Air Force, the United Kingdom's Royal Air Force and the Royal Norwegian Air Force.

MoD and Arjun Mk-1A

"The indigenous Main Battle Tank (MBT) Arjun Mk-1A designed and developed by the Defence Research and Development Organisation (DRDO) is compatible with the present and future requirement of Armed Forces. MBT Arjun Mk-1A is incorporated with 71 upgrades in comparison to MBT Arjun Mk-1, thereby endowed to have superior fire power, enhanced high mobility and excellent protection characteristics required to fulfil the challenging requirements of the battlefield".

Indian Navy tests extended range Brahmos land attack missile



The Indian Navy successfully demonstrated the accuracy of an extended-range land attack Brahmos supersonic cruise missile from the stealth destroyer INS Chennai on 5 March, 2022. The missile hit its intended target with pinpoint accuracy after traversing an extended range trajectory and performing complex manoeuvres. Both Brahmos missile and INS Chennai are indigenously built and highlight the cutting-edge of Indian missile and ship-building prowess. They reinforce the Indian Navy's contribution towards the Atma Nirbhar Bharat and Make in India endeavours.

Launching of ICG auxiliary barge Urja Prabha

Indian Coast Guard auxiliary barge Urja Prabha launched on 5 March 22 by Viraj Sharma W/O IG DR Sharma PTM, TM, Deputy Director General at Shoft Shipyard, Bharuch. Urja Prabha is 36.96 mtr long with draft of 1.85 mtrs. It is designed to cargo ship fuel, aviation fuel and fresh water with a capacity of 50 ton, 10 ton and 40 ton respectively. The barge will enhance the Indian Coast Guard operations by extending logistics support to ICG ships deployed in sea at far flung areas for various charter of duties.

ICGS Saksham commissioned

Indian Coast Guard Ship Saksham, the fifth in the series of 105 m Offshore Patrol Vessels (OPVs) was commissioned at Goa. It is fitted with advanced technology, navigation and communication equipment, sensors, machinery, a 30mm 2A42 Medak gun and two 12.7 mm SRCG guns with FCS. The ship displaces approximately 2350 tons and is propelled by two 9100 KW diesel engines to attain a maximum speed of 26 knots. She has an endurance of 6000 nm at economical speed. The ship, on joining the Coast Guard fleet will be based at Kochi.

BEL to supply of 957 sights for T-90 MBTs

(Photo: MoD)

Providing a further boost to the 'Make in India' initiative of the Government of India in the Defence Sector, the Acquisition Wing of the Ministry of Defence signed a contract for Rs. 1075 crore with Bharat Electronics Limited (BEL) for the retro-modification of commander sight of Battle Tanks-T-90 on 24 February 2022. The retro-modification will be carried out in 957 T-90 tanks of the Indian Army.

The new retro-modified Commander sight employs a thermal imager capable of detecting the targets at 8 kms during day and night and a Laser Ranger Finder (LRF) to find the ranges accurately up to

5 kms, thereby enhancing its capability to engage target at longer ranges. With the corrections from ballistic software and LRF, the Commander of T-90 can detect, engage and neutralise the targets with phenomenal accuracy. The indigenously developed sight completed extensive evaluations under field conditions successfully.

KSSL and Dastani in JV

Kalyani Strategic Systems Limited (KSSL), a wholly owned subsidiary of Bharat Forge Limited has incorporated Sagar-Manas Technologies Limited (SMTL) on 7 March 2022 as a wholly owned subsidiary. SMTL has been incorporated pursuant to a Joint Venture Agreement executed between KSSL and Open Joint Stock Company Dastan Transnational Corporation Ltd with an aim to participate in joint upgradation and manufacturing/ providing solutions for marine and defence products which will be undertaken through SMTL as a special purpose vehicle. Dastan, a Kyrgyzstan entity, is a leading multipurpose enterprise engaged in the development, manufacturing, sale of defence equipment, electronic devices, medical centrifuges, etc.

SASMOS in MoU with HAL and NAeL

SASMOS HET Technologies Limited, a Bangalore-based manufacturer and developer of Electrical, Electromechanical and Electronics integrated solutions, has signed a Memorandum of Understanding (MoU) with Hindustan Aeronautics Limited (HAL) and its wholly-owned subsidiary Naini Aerospace Limited (NAel), to work together in the field of advanced electronics, electrical and Fibre optics interconnections in the aerospace domain. The MoU was signed on 11 March 2022 by Krishna, GM-HAL, Amit Mai Shrivastava , CEO NAeL and **S** Sethuraman, Director Sasmos in the presence of R Madhavan, CMD, Sajal Prakash, CEO HAL, H G Chandrashekar, Founder and MD SASMOS and other professionals including N V Maslekar, Director, Sasmos.

AZAD Engineering delivers first consignment of critical parts to Boeing

AZAD Engineering has successfully delivered on-time the first consignment of aviation parts to Boeing. The parts were delivered as part of its contract with the global aerospace company for manufacturing and supplying aviation parts and components. AZAD, a strategic supplier to Boeing, had won the contract in July 2021. The company set up a dedicated facility in record time and delivered the first batch of aviation parts on 24 February. These parts will be used in several Boeing airplanes.

Successful launch of PSLV-C52 with EOS-04 satellite

On 14 February 2022, the Polar Satellite Launch Vehicle PSLV- C52 successfully launched EOS-04 satellite from the first launch pad of Satish Dhawan Space Centre (SDSC), SHAR, Sriharikota. After a smooth countdown of 25 hrs 30 minutes the PSLV- C52 launch vehicle lifted off at 05:59 hrs (IST) in the opening of the launch window. The important flight events, namely, stage and strap-on ignitions, heat shield separation, stages and strap-on separation, satellite injection took place exactly as planned.

After a flight of about 17 minutes 34 seconds three satellites namely EOS-04, INSPIREsat-1 and INST-2TD were injected successfully into a sun-synchronous polar orbit of 529 km. The orbit achieved for the satellites is very close to the intended orbits.

Army Chief presents President's Colours to Parachute Regiment

General MM Naravane, the Chief of the Army Staff presented the prestigious 'President's Colours' to four battalions of the Parachute Regiment, namely 11 PARACHUTE (Special Forces), 21 PARACHUTE (Special Forces), 23 PARACHUTE and 29 PARACHUTE, during a Colour Presentation Parade held at the Parachute Regiment Training Centre, Bangalore on 23 February 2022.

EoI signed between Indian Navy and HAL

Indian Navy and HAL signed a 'Mutual Expression of Interest' to facilitate Faculty Exchange Programme between Naval Institute of Aeronautical Technology, Kochi and HAL Management Academy, Bengaluru on 24 February 2022. This association is aimed to facilitate development of key skill-sets amongst trainees to help them imbibe latest aviation technologies and Maintenance, Repair and Overhaul (MRO) management through conduct of short-term, long-term and capsule courses, guest lectures, workshops and conferences.

Western Air Command Commanders' Conclave

Western Air Command Commanders' Conclave was held on 24 February 2022 at Subroto Park, New Delhi. The conclave was attended by Commanders of all bases under Western Air Command (WAC). Air Chief Marshal VR Chaudhari, Chief of the Air Staff was received by Air Marshal Amit Dev, Air Officer Commanding-in-Chief WAC and was accorded a ceremonial Guard of Honour on his arrival at the Command Headquarters. In his address, Chief of the Air Staff emphasised the necessity to enhance operational preparedness and directed the Commanders to ensure operational readiness of all platforms, weapon systems and assets. He stressed on the need for root cause analysis of all accidents and incidents, improve maintenance practices to boost mission effectiveness besides maintaining impregnable physical and cyber security at all times. He praised WAC for the quantum of flying carried out and urged all Commanders to continue their efforts towards providing a safe operational flying environment.

Western Naval Command conducts meeting on Theatre Commands

Tri-services discussions on the modalities and structural framework for the creation of Integrated Theatre Commands for the Indian Armed Forces were held under the aegis of Western Naval Command at Mumbai. This is yet another milestone towards building jointness and enhancing organisational synergy among the three Services. A total of nine Commanders-in-Chief from the Indian Army, Navy, Air Force and ANC, came together for a high-level meeting to discuss and deliberate on various aspects related to setting up of the Integrated Maritime Theatre Command. The meeting was chaired by Vice Adm Ajendra Bahadur Singh, ADC, who has been nominated as the lead CinC for the Study.

SpiceJet to launch 60 new flights

SpiceJet has announced new flights in its Summer Schedule 2022, effective 27 March. The airline has added 60 new domestic flights to its schedule including seven UDAN flights, eight industry-first flights, new connections and additional frequencies. The airline will be deploying its Boeing 737 and Q400 aircraft on these routes.

YIAPL signs agreement with AAI

As part of the development plan for Noida International Airport (NIA), Yamuna International Airport Private Limited (YIAPL) has signed an agreement with Airport Authority of India (AAI) for the provision of Air Navigation Services which includes Communications, Navigation, and Surveillance Systems and Air Traffic Management (CNS/ATM). One of the conditions of the concession for NIA, the agreement defines terms and conditions for the provision of CNS/ATM services by AAI at NIA.

APPOINTMENTS

Air Marshal S Prabhakaran assumes command of WAC

Air Marshal Sreekumar Prabhakaran assumed command of Delhi based Western Air Command (WAC) on 1 March 2022. The Air Marshal is a graduate of National Defence Academy, Pune and was commissioned into the IAF as a fighter pilot on 22 December 1983. He is an alumnus of Defence Services Staff College (DSSC) Wellington and National Defence College, New Delhi. An experienced MiG-21 pilot and a category 'A' qualified flying instructor, Air Marshal Prabhakaran has nearly 5000 hours of flying experience.

MoD identifies 18 major platforms for design and development

In a significant boost to 'Aatmanirbhar Bharat Abhiyan' and in sync with the announcement in the Union Budget 2022-23 that allocated 25% of Defence R & D Budget for industry led R & D, 18 major platforms have been identified by the Ministry of Defence for industry led Design & Development under various routes. The list is as follows:

Under the Make-I category are:
Hypersonic Glide Vehicle
Directed Energy Weapons (300 KW and more) [High Powered Electromagnetic Devices and High Powered Laser Devices]
Naval Ship Borne Unmanned Aerial System (NSUAS)
Light Weight Tank
Self-Healing Mine Fields
Unmanned Autonomous AI Based Land Robot
127 mm Naval Gun
127 mm Guided Projectile
Electric Propulsion (Engines) for Ships
Standoff Airborne Jammer
Li-ion Cells/ Li-Sulphur Cells [Portable High Capacity Energy Systems replacing the Conventional Hydrocarbons
Communication System (AFNET System Switches, routers, Encryptors& VOIP phones)
Electro Optical (EO) Pod (with subsequent upgrade to EO/IR) with high resolution sensing
'Plug and Play' Housing/ Infrastructure for soldiers posted at extreme altitudes.

Under the Defence Acquisition Procedure 2020, 'Make' Category aims to achieve self-reliance by involving greater participation of Indian industry. Projects involving design and development of equipment, systems, major platforms or upgrades thereof by the industry can be taken up under this category. For Projects under Make-I sub-category, Ministry of Defence will provide financial support up to 70% of total cost of prototype development.

Special Purpose Vehicle (SPV) Model: Under SPV model, private industry will be encouraged to take up design and development of military platforms and equipment in collaboration with the Defence Research and Development Organisation (DRDO) and other organisations. Following two platforms have been identified under this category- Long Range Unmanned Aerial Vehicles (UAVs) [High Altitude Long Endurance (HALE)] and Indian Multi Role Helicopter (IMRH)

iDEX: Projects of Start-ups, MSMEs etc. involving high-end innovation would be pursued under the iDEX category and the following platform has been selected under this category- Low Orbit Pseudo Satellites.

Under Make-II, which is funded by industry with assured procurement, the following platform has been listed- Anti-jamming Systems for Multiple Platforms.

Out of 18 major platforms mentioned above, following four platforms have been already accorded Approval-In-Principle (AIP) under Make-I category on 3 March 2022: Communication System (AFNET System Switches, routers, Encryptors & VOIP phones); EO Pod (with subsequent upgrade to EO/IR) with high resolution sensing; Standoff Airborne Jammer and Light Weight Tanks.

The indigenous development of these projects "will help harness the design capabilities of domestic defence industry and position India as a design leader in these technologies".

The President's Fleet Review

President and Supreme Commander of the armed forces of India, Mr. Ram Nath Kovind reviewed the Indian Navy Fleet at Visakhapatnam on 21 February 2022. With the theme *'75 years in Service of the Nation'*, the Indian Navy showcased its latest state-of-art indigenously built combat platforms during the 12th edition of the Fleet Review which was also conducted as part of the 75th anniversary of India's Independence being celebrated as 'Azadi Ka Amrit Mahotsav'.

After a 21-Gun Salute and Ceremonial Guard of Honour, the President embarked on the Presidential yacht, INS Sumitra, an indigenously built naval offshore patrol vessel designated as the Presidential yacht. The President was received by the Raksha Mantri Rajnath Singh and Admiral R Hari Kumar, the Chief of Naval Staff. The Yacht sailed past 44 ships from the Indian Navy, Coast Guard, SCI and MoES lined up in four columns at anchorage off Visakhapatnam, exhibiting the nation›s maritime power in full display. A spectacular flypast was conducted as a part of the static review of the Fleet. During the final stage of the review, a mobile column of warships and submarines carried out high-speed steam past alongside the Presidential yacht. Several enthralling waterfront activities by Parade of Sails, search and rescue demonstration at sea, aerobatics by Hawk aircraft and water para jumps by the elite Marine Commandos (MARCOS) were performed.

As the Presidential yacht passed between the review columns, each ship dressed in full regalia, manned by her ship›s company saluted the President with traditional «Three Jais» in a demonstration of the unconditional allegiance to the country and the Supreme Commander. The President also witnessed demonstrations in the form of a composite flypast by 55 aircraft including Chetaks, ALHs, Sea Kings, Kamovs, Dorniers, Il-38SD, P8I's, Hawks and MiG-29K's.

Exercises and visits

JGSDF in "Ex Dharma Guardian-2022"

A joint military exercise, "Ex Dharma Guardian-2022", between India and Japan was conducted at Foreign Training Node, Belagavi (Belgaum, Karnataka) from 27 February 2022 to 10 March 2022. This is an annual training event conducted in India since 2018. Notably, in the series of military training exercises undertaken by India with various countries, this exercise with Japan is crucial and significant in terms of security challenges faced by both nations in the backdrop of current global situation. The scope of this exercise covers platoon level joint training on operations in jungle and semi urban/urban terrain.

Combat experienced troops of the 15th Battalion the Maratha Light Infantry Regiment of the Indian Army and 30th Infantry Regiment of Japanese Ground Self Defence Forces (JGSDF) participated in the exercise this year to share experiences gained during operations in order to enhance inter-operability in planning and execution of various operations in jungle and semi urban/urban terrain.

The 12 days long joint exercise schedule included house interventions drills, raid on terrorist hideouts in semi urban terrain, combat first aid, unarmed combat and close quarter combat firing where both sides jointly trained, planed and executed a series of well-developed tactical drills for neutralisation of likely threats.

Exercise Eastern Bridge-VI

The Indo-Oman exercise, Eastern Bridge-VI (2022) was successfully conducted at Air Force Station Jodhpur from 21 to 25 February 2022. Royal Air Force of Oman (RAFO) participated with Indian Air Force (IAF) in the exercise which was aimed at providing operational exposure and undertaking mutual exchange of best practices, towards enhancing operational capabilities of both Air Forces.

Senior officers from both sides who visited Air Force Station Jodhpur during this exercise included RAFO's Director General Operations and IAF South Western Air Command's Senior Air Staff Officer. They discussed further prospects of mutual co-operation. The exercise provided an opportunity for fruitful interaction between IAF and RAFO elements through mutual exchange of experience and operational knowledge. It also provided avenues of cultural exchanges between the personnel of both countries.

Sri Lanka-India SLINEX'22

The Ninth Edition of India-Sri Lanka Bilateral Maritime Exercise SLINEX (Sri Lanka–India Naval Exercise) took place at Visakhapatnam from 7-10 March 2022. The exercise was being conducted in two phases; the Harbour Phase at Visakhapatnam on 7-8 March 22 followed by the Sea Phase on 9-10 March 22 in the Bay of Bengal.

Sri Lanka Navy was represented by SLNS Sayurala, an advanced offshore patrol vessel and the Indian Navy by INS Kirch, a guided missile corvette. Other participants from the Indian Navy included INS Jyoti, a Fleet support tanker, Advanced Light Helicopter (ALH), Seaking and Chetak helicopters and Dornier maritime patrol aircraft. The previous edition of SLINEX was conducted off Trincomalee in October 2020. SLINEX aims to "enhance inter-operability, improve mutual understanding and exchange best practices and procedures for multi-faceted maritime operations between both navies. These will further enhance the high degree of inter-operability already existing between the two navies".

INS Chennai and INS Teg visit Colombo

Ships of the Indian Navy's Western Fleet, INS Chennai and INS Teg, made a port call at Colombo, Sri Lanka on 10 March 22 for a two day visit. They were received by the Officer of the Guard (OOG) and Sri Lanka Navy band. Upon arrival, Rear Admiral Sameer Saxena, NM, Flag Officer Commanding Western Fleet (FOCWF) visited the IPKF memorial to pay homage to the soldiers that sacrificed their lives for peace in the region. The memorial is also testimony to the inextricable ties between the people of India and Sri Lanka.

Integrated Fire Power Demonstration at Pokharan

On 10 March 2022, Lt Gen Richard Maxwell Burr, the Australian Army Chief visited Laungewala, Pokharan and Jodhpur in Rajasthan. On arrival at Laungewala, the Australian COAS was received by Lt Gen Rakesh Kapoor, GOC, Desert Corps after which he paid homage at the Laungewala War Memorial in memory of the fallen heroes of Indian Army in the Indo-Pak War 1971. He appreciated the efforts of Indian Army in creating and maintaining the 'War Memorials' and establishing a bridge for common man's outreach to witness the values and valour of the Indian Soldier.

Lt Gen Richard Burr also visited the Pokharan Field Firing Ranges where he witnessed a demonstration of indigenised weapons platforms executing operational manoeuvres in a combined arms firing exercise involving armour, artillery, infantry and aviation assets. The visiting General complimented the robustness of the Indian soldier and his ability to operate in varied terrain and difficult conditions, across various spectrums of engagement.

Indian Navy's multi-national exercise MILAN-2022

The latest edition of Indian Navy's multilateral exercise MILAN 2022 was scheduled from 25 February 2022 in the 'City of Destiny', Visakhapatnam. MILAN 22 was conducted over a duration of 9 days in two phases with the harbour phase scheduled from 25 to 28 February and Sea Phase from 1 to 4 March 2022. India is celebrating the 75th year of its independence in 2022 and MILAN 22 provided an opportunity to commensurate this milestone with our friends and partners. The theme of the MILAN 2022 exercise was 'Camaraderie – Cohesion – Collaboration' which was aimed to project India as a responsible maritime power to the world at large. The purpose of the exercise was to hone operational skills, imbibe best practices and procedures, and enable doctrinal learning in the maritime domain, through professional interaction between friendly navies.

About MILAN

MILAN is a biennial multilateral naval exercise incepted by Indian Navy in 1995 at Andaman and Nicobar Command. Since its inception, the event has been held biennially except for 2001, 2005, 2016 and 2020. While the 2001 and 2016 editions were not held due to International Fleet Reviews, the 2005 editions was rescheduled to 2006 due to the 2004 Tsunami. 2020 edition of MILAN was postponed to 2022 due to COVID-19. Starting with the participation of only four countries, viz Indonesia, Singapore, Sri Lanka and Thailand, in the 1995 edition,

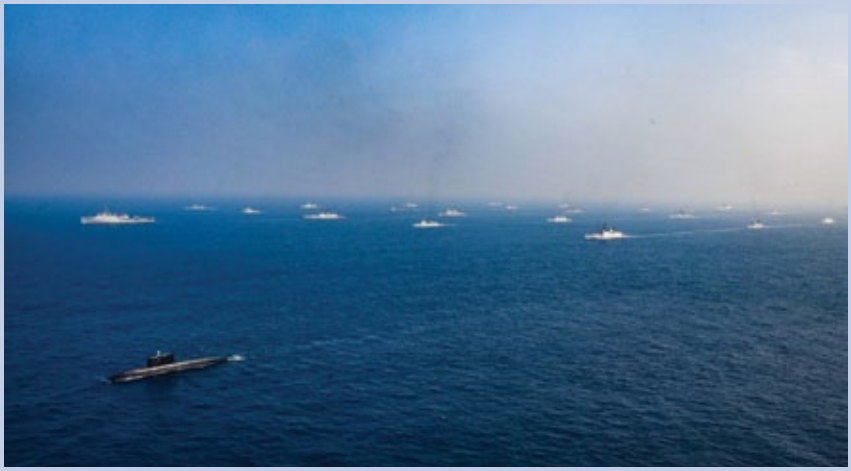
Multilateral naval exercise MILAN 22 concludes

CO's of the India and other participating countries assembled at INS Jalashwa with RAdm Sanjay Bhalla

The sea phase of the 11th edition of MILAN which witnessed participation of 26 ships, one submarine and 21 aircraft, culminated on 4 March 22. A series of complex and advanced exercises were undertaken in all three dimensions of naval operations to enhance compatibility, interoperability, mutual understanding and maritime cooperation amongst the partner Navies. The first two days of exercises at sea included complex Anti Air Warfare drills with US P8A aircraft shepherding a strike of Indian fighter aircraft on a formation of warships of the participating navies. Additionally, weapon firings against low flying air targets were conducted, which reflected the proficiency of the crews and high levels of interoperability.

IN submarine operating with ships from multiple nationalities during exercise MILAN 22 sea phase

Indian Navy ships crew bidding adieu to personnel of foreign ships post completion of sea phase of the exercise



Rendezvous at Sea, a total of 27 ships manoeuvring in formation marking the culmination of the MILAN

During helicopter operations, cross deck landing operations were carried out. Ships from participating countries also exercised for replenishment at sea with Indian Navy's tanker which requires precise manoeuvring and seamanship skills. The next few days witnessed an increase in the complexity of exercises including underway replenishment, advanced anti-submarine exercises with participation by aircraft, surface target firings and simulation of complex operational scenarios. The Closing

Rear Adm Sanjay Bhalla Flag Officer Commanding Eastern Fleet delivering the closing address of exercise

Ceremony of MILAN 22 was held in a unique format with Commanding Officers of participating ships arriving by helicopters and boats onboard INS Jalashwa at anchorage. Six foreign ships attended the Closing Ceremony in virtual mode. The ceremony was presided over by RAdm Sanjay Bhalla, Flag Officer Commanding Eastern Fleet. The ceremony included a debrief of the exercises conducted at sea. Commanding Officers of participating countries expressed their appreciation for the well-conducted harbour and sea phase of MILAN 22.

VPNS Quang Trung (016), a Gepard Class Frigate (Guided Missile) of Vietnamese People's Navy (VPN)

the exercise has since transitioned leaps and bounds in terms of number of participants and complexity of exercises. Originally conceived in consonance with India's 'Look East Policy', MILAN expanded in ensuing years with the GOI's 'Act East policy' and Security and Growth for All in the Region (SAGAR) initiative, to include participation from island nations in the Western IOR as also IOR littorals. Participation increased from six regional countries to 18 countries in 2014 which included IOR littorals.

With Indian Navy's engagement with Friendly Foreign Countries (FFCs) expanding over the decades, a need was felt to further consolidate the naval cooperation by enhancing the scale and complexity of the MILAN exercise and engaging both regional and extra regional navies of the world. Considering the infrastructure requirements of a large naval gathering, it was decided to shift the event to mainland, and Visakhapatnam, being the Headquarters of Eastern Naval Command, was nominated to host the event.

This edition

MILAN 22 witnessed its largest ever participation, with more than 40 countries sending their warships/ high level delegations. This edition of MILAN was larger in 'scope and complexity' with focus on exercises at sea including exercises in surface, sub-surface and air domains and weapon firings. Operational conferences and seminars were conducted, providing participating navies/ delegations an opportunity to express their views on maritime security. The high profile foreign delegates comprised highest level naval leadership, agency heads, Ambassadors and equivalent.

Key Events

Key events planned during MILAN 22 included an Opening Ceremony followed by inauguration of MILAN Village on 26 February. An Op Demo followed by International City Parade was scheduled on the evening of 27 February with participation of foreign contingents. MILAN 22 hosted an International Maritime Seminar with the theme - 'Harnessing Collective Maritime Competence through Collaboration' on 27-28 February. Other activities included Professional/ Subject Matter Expert Exchanges, DSRV demonstration, MILAN of Young Officers, Sports Fixtures, and

SLNS Sayurala (P623), the Advanced Offshore Patrol Vessel of Sri Lanka Navy (SLN)

FS Loire (A602) an Offshore Support and Assistance Vessel of the French Navy

P8A the multi-mission maritime patrol and reconnaissance aircraft of the US Navy

HMAS Arunta (151), an Anzac Class Frigate (Guided Missile) of Royal Australian Navy (RAN)

Cultural Visits to Agra and Bodh Gaya for foreign visitors. The Sea Phase of the exercise for countries participating with ships/ aircraft was scheduled from 1-4 March 2022.

Fostering bonds across the oceans

Indian Navy is an instrument not only for power projection, but also for diplomatic outreach. Towards this, conduct of joint/ multi-lateral exercises is an important activity to bring together different Navies. While Navies may operate in different regions, there is always a need to co-operate on issues of common interest such as anti-piracy, HADR missions, maritime security etc. Navy to Navy interactions enhance mutual understanding, cooperation and inter-operability between maritime forces. MILAN 22 provided an "invaluable opportunity to foster bonds of maritime brotherhood across the oceans".

KRI Eddy Martadinata (331), a Martadinata class of guided-missile frigate of the Indonesian Navy

BNS Umar Farooq (F 16), a Helicopter carrying Frigate of the Bangladesh Navy

KD Lekiu (30), a Lekiu Class Frigate of Royal Malaysian Navy (RMN)

Interview with Anandi Ramalingam, Chairman & Managing Director – Additional Charge, BEL

How is your order book position? Tell us about the key orders executed during FY 2020-21 and major orders for this financial year from Defence and Non-Defence space?

BEL's overall order book stands at Rs.57,636 Crores as on 31 January 2022. The major projects executed in FY 2020-21 were LRSAM, Air Defence Weapon System, CDR TI for BMP & T72, Land-based EW System Upgrade, AFNET, Ventilators, Homeland Security, Smart City projects, Coastal Surveillance System, K-FON, SDR (NC), EOIR, CCTV, Avionics for Light Combat Aircraft, Electronic Fuzes, NAISS and Low Level Transportable Radar.

BEL has acquired orders worth about Rs. 14,000 Crores in FY 2021-22. Major Orders received include AFNET Performance & Security Enhancement and SATCOM Network, Ventilators (including service), Naval Fire Control System, Software Defined Radio, Advance Torpedo Defence Systems, Digital Mobile Radio Relay, etc.

Some of the major projects planned for execution during 2021-22 are Long Range Surface to Air Missile System (LRSAM), Coastal Surveillance System (CSS)-Phase II, Kerala Fibre Optic Network (K-FON), Weapon Locating Radar (WLR), Integrated Perimeter Security System (IPSS), EW Upgrade System, Naval Gun Fire Control System, Electronic Voting Machines (EVM), etc.

Please tell us about BEL's exports. What are the major products and who are the customers?

BEL achieved an export sale of 51.93 Million USD during FY 2020-21. Some of the countries, where BEL's products were exported were USA, France, Israel, Germany, Switzerland, Sweden, China, Republic of Armenia, Maldives, Indonesia, Sri Lanka, Turkey, Bhutan and few specific SEZs. The major products/ systems exported during the year included Coastal Surveillance System, Data Link II, EOS CoMPASS, IFF-I Mk-XI, Radar Finger Printing System, Communication equipment, TR Modules, Vacuum Interrupters, mechanical parts, cable looms, radar spares, sub assembly of Radar & EW Systems, assemblies and sub-assemblies of Missile Systems, Shelter Spares, Electronic Fuzes, etc.

The Export order book, as on 31 January 2022, stands at US $347.28 Million including Offset orders of US $157.99 Million. BEL is fast expanding its global presence, putting its best foot forward to give a thrust to exports worldwide. All-out efforts are being made to tap new markets across the globe. In a bid to develop new markets in the Indian Ocean Region (IOR) and friendly foreign countries (FFCs), BEL

Air Defence Weapon System

D-4 Antidrone System

Could you brief us on some of BEL's important programmes for which tie-ups have been forged with leading defence and aerospace firms worldwide?

BEL has active collaborations with top Defence and Aerospace firms. In some specific niche technology areas, BEL does look for collaboration with foreign firms to meet the requirement of Indian customers. Similarly for various programmes of foreign OEMs, BEL is the preferred supply chain partner.

BEL is at present executing an order from ELOP, Israel, for EOIR Payloads (CoMPASS) and other airborne systems. The Company is involved in the manufacture and supply of systems/ subsystems required for missile systems for IAI, Israel. BEL is also working on the development of software for a C4I solution for Rafael, Israel.

BEL is supplying RF Super Components to Thales through a JV between BEL and Thales (BTSL), for Rafale aircraft. BEL is also working with several OEMs in USA and Russia for various products and systems such as Data Link II, IFFI (Identify Friend or Foe Interrogator), etc. Apart from these, the Company is actively interacting with many other OEMs such as Elisra (Israel), Telephonics (USA), and Saab (Sweden), to explore aerospace related business opportunities.

Low Level Light Weight Radar

has operationalised overseas marketing offices in Oman, Vietnam, Sri Lanka and Myanmar. BEL has also expanded its Singapore and New York Regional Offices to handle marketing activities.

The Government is encouraging defence exports through many policy initiatives and has set a target of Rs.35,000 Crs by 2025. BEL has identified Exports & Offsets as one of its thrust areas and has drawn up plans to offer its select products and systems to various export markets.

Some of the other products and systems which are being promoted for exports include Homeland Security solutions, Smart City solutions, Border Protection Systems and Coastal Surveillance System. Having established a Coastal Surveillance System (CSS) for a few neighbouring countries, BEL is interacting with the Ministry of External Affairs for supply of CSS to other friendly countries.

BEL is also focusing on Offset as a potential avenue for revenue generation. BEL is interacting with many foreign OEMs to meet Offset obligations in various programmes of the MoD. BEL has identified contract manufacturing (build-to-print and build-to-spec) for foreign OEMs and partnerships in the form of Transfer of Technology of the latest systems and solutions as areas of emerging export opportunities. Efforts are also on to establish long term supply chain relationship with global players.

Software Defined Radio manpack

Could you tell us about BEL's ongoing programmes with the Indian Air Force?

One of major ongoing programme is Air Defence Weapon System, which is currently under execution. This is a turnkey contract with an additional requirement of setting up specialised infrastructure.

The other major programmes are Integrated Air Command and Control System (C4I System developed for IAF), Integrated Perimeter Security System, Radar Warning Receivers (RWRs) for aircraft of IAF, Missile Warning Systems, Self Protection Suite, EW Suites, etc.

BEL has been supplying a range of products, systems and services for the Indian Air Force, which include Electronic Warfare Systems, Avionics, Weapon Systems, Radar and Fire Control Systems, Communication systems, C4I Systems, Homeland Security, EO Payloads for Helicopters, Counter Drone Systems, etc.

BEL's airborne EW products include Radar Warning Receivers for aircraft and helicopters, new generation Integrated EW Suites for fighter aircraft and Self-protection Suites for helicopters with light-weight RWR, laser and missile warning capabilities, state-of-the-art Jammers, etc.

BEL has been actively associated with the prestigious Light Combat Aircraft (Tejas) programme since 1994. BEL has been partnering for many years with various DRDO labs like ADE, ADA and DARE in the development and manufacturing of various avionics grade systems for the LCA. BEL's avionics products for Tejas include flight-critical equipment like the Digital Flight Control Computer, Flight Control Panel, Air Data Computer, Mission Critical Line-Replaceable Units (LRU) like Pylon Interface Box and Stores Interface Box, Head Up Displays, Cockpit Modules and Data Link equipment.

BEL is actively participating in the MRSAM weapon system programme of the Air Force, which is a joint development programme between DRDO and IAI, Israel, by supplying sub-systems such as Combat Management System, IFF Mk II, etc, for the weapon system.

BEL has been supplying various Radars for Air Defence, Surveillance and Fire Control to the Indian Defence Forces since many decades.

In the area of Communication, BEL has developed the Software Defined Radio (Airborne) version. Software Defined Radios (SDRs) are multiband, multirole radios. These radios are backward compatible, inter-operable with legacy radios and capable of high data rates. BEL is engaged in projects such as TROPO upgrade, Mobile Radio Relay (DMRR) upgrade, Communication terminals for Advanced Landing Ground (ALG), etc, for the IAF.

In order to strengthen the security infrastructure of critical assets, BEL is executing the Integrated Perimeter Security System for IAF. Similarly in the Unmanned Systems domain, BEL is engaged in the design, development, manufacturing and supply of Payloads and Ground Control Stations for UAVs.

BEL has also developed various C4I or Network Centric Systems for the Indian armed forces to network and provide a Digital Battle Space for geologically dispersed forces.

Tell us about your initiatives to diversify into the civilian business?

Defence, being the mainstay of BEL, has traditionally been contributing to around 80% of the Company's annual sales revenue. BEL, however, has been continuously exploring opportunities in allied non-defence areas. The Company aims to increase its non-defence share in the overall business in the coming years. The total opportunity in the non-defence business segment being pursued by BEL in the next 10-15 years is more than Rs. 2 Lakh Crores.

Some of the areas BEL is focussing on in non-defence include solutions for Civil Aviation sector including Air Traffic Controller Radars, Anti Drone systems, Space / Satellite Electronics, Space Launch Vehicles, Satellite Communication Services,


Tethered UAV

Weapon Locating radar-BEL

Spacegrade Solar Cells, Unmanned Systems, Satellite Assembly & Integration, Solar Business, Railway and Metro solutions, Software as a Service, Network & Cyber Security, Energy Storage products for Electric Vehicles (Li-ion & Fuel Cells, Charging Stations, etc), Homeland Security & Smart City businesses, Smart Meters, a range of Medical Electronic and health care solutions (ICU Ventilators, Dialysis Machines, Patient Monitoring System, UV Sanitiser, Telemedicine, Medical Simulators, Portable CT Scan, Medical Displays, X-ray C Arm, Ultra Sound, MRI, etc), Artificial Intelligence, Communication Radios & Networks, Composite Shelters & Masts, etc. This wide bouquet of businesses in non-defence would play a key role in driving BEL's growth in the coming years.

In recent years, the Government of India has stressed on the need to involve the MSMEs, private industry and start-ups in the Defence sector. What are BEL's initiatives to promote such initiatives?

The Defence Sector is being opened up for private sector participation with the evolution of Defence Procurement Procedure. In this changing business scenario, BEL is focusing on enhancing interactions at various levels and building long-term relationships with customers, emerging Strategic Partners and other key stakeholders in the Indian Defence industry as a trusted and committed partner.

Be it the efforts that the Company has been putting in to engage in collaborative R&D in addition to augmenting its own R&D set up — its recent attempts to outsource work to Indian private industries and MSMEs, or the path breaking decision to go in for Public-Private partnerships to execute turnkey projects, BEL is leaving no stone unturned to ensure that it is in sync with the Government's larger goal of indigenisation and self-reliance.

BEL has formulated a long-term Outsourcing and Vendor Development Policy and has been taking several initiatives in order to broaden the domestic vendor base by implementing online vendor registration and e-procurement processes including GeM. This is in line with the 'Make in India' initiative where enhanced thrust has to be put to develop domestic players. BEL has also made provisions for entering into Long Term Agreements (LTAs) with reputed vendors with an objective to secure the supply of items or services over a specified period of time as per mutually agreed terms and conditions. Make in India Display Cells have been established at all Units of BEL. The procurement from MSMEs by BEL has been over 20% in the previous years. BEL also takes part in various events organised by the Government of India to promote MSMEs.

Startup India is a flagship initiative of the Government of India, intended to build a strong ecosystem that is conducive for the growth of startup businesses, to drive sustainable economic growth and generate large scale employment opportunities. BEL has identified several areas for partnership with start-ups in new emerging areas including Machine Learning, Cyber Security, Artificial Intelligence, Embedded Computing and other latest technologies which can be used for Defence electronics applications.

Defence Innovation Organisation (DIO) is a Section-8 company, created jointly by BEL and HAL to support the country in building an eco system of entrepreneurship and innovation in Defence in India by implementing the iDEX framework. iDEX is aimed at fostering innovation and technology development in Defence & Aerospace by engaging industries including MSMEs, Startups, individual innovators, R&D institutes and academia and providing them R&D grants. iDEX will function as the executive arm of the DIO.

The Company is also working on emerging technologies such as Artificial Intelligence, Big Data Analytics, Internet of Things, 5G Wireless Communication, Robotics & Computer Vision, Augmented & Virtual Reality, Quantum Cryptography, etc, under R&D collaboration with academia and Start-ups.

Exploring Tejas scope of success with Malaysia

LCA Tejas

The Indian aerospace industry since its inception has generally focused on fulfilling the domestic needs of the nation instead of investing in major scale marketing to promote exports. Since the foundation of state-owned Hindustan Aeronautics Limited (HAL) on 1 October 1964, the 58 years of journey (and counting) has seen the firm mass-producing an array of products on license from foreign OEMs as well as locally researching and developing indigenous designs. Light aircraft, trainers, UAVs, helicopters, fighter jets, and even engines, HAL managed to acquire decent experience with the development of a variety of solutions. While major designs in the domains of light aircraft, trainers, and helicopters managed to make it through the phase of designing and entered the production line with successful execution, complex concepts like jet fighters are yet to see major success. The very first jet rolled out in India for combat was introduced in 1961 as HF-24 Marut, a twin-engine attack aircraft deriving its design from IAe 43 "Pulqui III", one of the earlier concepts produced by chief designer Kurt Tank in 1954 (An year before arriving in India) but originally for Argentine Air Force while he was working at IAME (State Aeronautical and Mechanical Industries). The cancellation of the aircraft in Argentina led to its employment for Indian requirements, which allowed the authorities to shorten the design timeline as they pitched the continuation of a design from drawing board in Argentina to a proper physical product in India, that served for more than 23 years (1967-1990) in Indian Air Force, scoring excellency both during peacetime and wartime.

While it can be said that New Delhi's first jet fighter had somewhat a German "DNA" (as Mr. Tank had German origin), the second and latest member of the

family, Tejas, offers some significant highlights to look upon while discussing the advancement of India in the field of aerospace developments. The aircraft that took its first flight in 2003 is now valiantly offering an operational strength of two squadrons in the Indian Air Force, albeit in base Mark 1 standard. Very soon, squadrons will be shifted to forward operating bases as their first step to replace the vintage MiG-21 Bison, the objective for which the LCA programme was initiated in the 80s. However, while future of the type is already planned with upgraded Mark 1A [Alpha] spec and evolution into next-generation Medium Weight Fighter (MWF), HAL is optimistic to give a boost to the programme by making a mark in the global market as well, where the platform is now on offer for nations seeking a plausible and affordable platform to strengthen their airpower.

Understanding Malaysian LCA/ FLIT tender

The Malaysian administration since 2018 has hinted on multiple occasions that the Royal Malaysian Air Force is looking at plausible options of lightweight fighter aircraft to modernise the fleet and replace the aging systems in service. However, sudden aggression from mainland China and the violation of Malaysian airspace by 16 Chinese fighter aircraft on 2 June 2021, had caused fast-tracking of the process and eventually led to the formal release of the tender within 20 days of the incident. The tender document lists down various characteristics and specifications that the Original Equipment Manufacturers (OEMs) must ensure to feature in their proposals, which will make the platforms suitable to undertake missions as per RMAF operating procedures.

As a part of RMAF's modernisation program termed as the Capability Development Plan 2055 (CAP55), the tender involves an acquisition process for new and advanced fourth-generation Light Combat Aircraft (LCA) to replace the aging fleet of Bae Hawk Mk-208 and Hawk Mk-108 light aircraft. The Fighter Lead-In Trainer (FLIT), will be procured to replace Aermacchi MB-339CM, and expected to be a variant derived from the same LCA type: in simpler words, a twin-seat variant of the LCA primarily for conversion training as well as satisfactory combat role.

A total of 9 companies were invited, via a Request for Proposal (RFP), to offer their products till September 22 (later extended to 6 October). Six companies responded which included Italy's Leonardo with M-346 "Master", China's CATIC with L-15 "Falcon", Korean Aerospace Industries (KAI) with FA-50/T-50 "Golden Eagle", Turkey's TAI with "Hürjet", India's HAL with "Tejas" and Russia's Rosoboronexport with MiG-35 "Fulcrum-F".

The procurement will be done in two batches or phases, each phase consisting of the acquisition of 18 jets, of which 10 airframes will be dedicated to LCA and the rest 8 will be twin-seat FLIT variants, with the final composition of 2 squadrons of LCA and 1 squadron of FLIT. The OEM needs to assure Malaysia that it will start delivery of the platform within 36 months after the deal is signed. This government-

Astra Beyond Visual Range Air-to-Air Missile (BVR-AAM)

Mockup of the Uttam Active Electronically Scanned Array Radar (AESAR) on the Tejas

to-government US$960 million deal will witness half proportion of the payment of barter nature that is palm oil worth US$480 million. Furthermore, the OEM needs to establish a joint venture with a domestic entity to obtain 30% of the products or services of Malaysian origin. This includes the production of airframe components, maintenance facilities, and more.

Three firms, TAI, HAL, and Rosoboronexport agreed to comply with every term in the context of offering participation of Malaysian firms in the deal. TAI plans to set up its engineering and design office in Malaysia, indicating its ambition to jointly produce the aircraft and set up a second production facility in Malaysia as well.

What does Tejas bring to the table?

Though Tejas Mark 1A is yet to take the skies in its maiden flight, a lot of information on its technical and performances are already well broadcasted, including 43 "improvements" over the base Mark 1, the first production variant. The upgraded aircraft will bolster the composition of Indian origin components, as various critical subsystems which are presently owned by foreign OEMs will be replaced by Indian substitutes, that includes Uttam Active Electronically Scanned Array Radar (AESAR), Advanced Self-Protection Jammer (ASPJ), Astra Beyond Visual Range Air-to-Air Missile (BVR-AAM), diverse air-to-ground weapon package and more. This reduces the chances of embargo due to foreign influence in case of disputes between the customer and the third party. Apart from this, all the capabilities arriving with the system comfortably fit the necessity of any modern era force looking to absorb a capable LCA to deal with the contemporary warfare scenario.

Challenges

There are challenges however that need to be tackled and only then it will ensure the potential customer that HAL has the capacity to take its step in this competitive market and be as capable as the executive of the aerospace industry like Lockheed Martin, Dassault, etc. First is having satisfactory production capacity where an adequate number of the airframes needed to be rolled out from factories to complete the delivery to both domestic and foreign customers before the deadline. The Indian Air Force is reportedly yet to receive an entire lot of 40 Tejas Mark 1 fighters ordered to arm the two squadrons, No.45 "Flying Daggers" and No.18 "Flying Bullets". Former operates with IOC configured airframes which will soon go through the FOC upgrade phase while the latter is operating with 8 units as per the latest report in February 2022. Second is the after-sales support, in which the logistics must be available in the form of spares so that the fleet remains active. Malaysia had recently grounded its entire fleet of MiG-29N "Fulcrum" aircraft due to lack of spare parts and went ahead to reduce the financial burden that was being caused to keep the Russian jets flying.

Conclusion

It is about time what the Malaysian government and RMAF decide to pursue, as winner of the tender is believed to be announced by mid-2022. For HAL, trying to compete with some of the renowned and established firms in the aviation market, is no less than a test and at the same time, an opportunity to edge out the critics and introduce the world to a fighter that reflects the skills of "Aatmanirbhar Bharat" that is equivalent or better than the expensive counterparts originated in other parts of the globe.

Article by Rishav
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(All photos: Vayu)

Sources: janes.com, business-standard.com, indiatoday.in, malaysiandefence.com and sinarharian.com (Local Malaysian media)

VAYU Interview with

Amit Banerjee, CMD, BEML & AK Srivastava, Director Defence Business, BEML

Amit Banerjee, CMD, BEML

AK Srivastava, Director Defence Business, BEML

VAYU : How does BEML contribute to the modernisation of India's armed forces? What are the ongoing projects in the defence sector?

BEML: BEML is in intense competitive environment across all its business verticals and more than 85% of its business is coming through open competition. Modernisation of facilities and upgradation of products is essential to be on par with global players.

BEML is steadily upgrading its manufacturing facilities, IT infrastructure and R&D facilities and CAPEX is about Rs. 50 Crs. to Rs. 70 Crs. per year. BEML is going for outsourcing wherever capability/ capacity is available in the private sector and generally restricts capital expenditure only to add machines for carrying out very critical operations. The Company's CAPEX is funded through internal accruals and borrowed funds.

BEML has taken up many projects to support the modernisation of Indian Armed forces, which includes development of improved cabins for high mobility vehicles and introducing AI based systems in existing vehicles. Following AI based projects have been taken to serve the Armed Forces: Medical Health Diagnostic System, Autonomous Dozer for snow clearing application, intelligent machine controlled robotic arm for weapon loading, Lighting Control System on HEMM and finally Autonomous All Terrain Surface Vehicle.

VAYU : How strong is BEML's international business and how do you intend to expand it? What are the major products on export and who are the clients?

BEML: BEML has an exclusive International Business Division (IBD), working in tandem with marketing divisions for the execution of export orders. BEML has exported its products to around 68 countries across the globe. Considering the prevailing market conditions, BEML's experience base and future aspirations, the geographical countries/regions that are of interest to BEML for exports are African countries: Nigeria, Ethiopia, Ghana, Kenya, Tanzania, Senegal, Zambia, Tunisia, Malawi and Cameroon; SAARC countries: Bangladesh, Sri Lanka, Nepal and Middle East countries: Oman, Egypt, Saudi Arabia.

BEML will expand the export business through various strategies:

- Enhancing market network by way of appointing distributors/representatives in various countries.
- Written to 25 defence attaches in Africa, Middle East and neighbouring countries for export of defence products.
- Registered in defence portals of foreign countries like Philippines and Singapore.
- Kenya region has been allotted to BEML by DDP for carrying out all the export promotional activities on behalf of all DPSUs/OFB. BEML branch office at Kenya has been registered since January 2021.
- Organised global outreach programme with EXIM Bank of India and ECGC for promotion of BEML defence products through EXIM Bank's global offices.
- Organised Webinars in Senegal, Kenya, Zambia, Azerbaijan, Saudi Arabia, Abu Dhabi, Oman and Sri Lanka for promotion of defence exports.
- Brand building and visibility through international exhibitions.

Armoured Recovery and Repair Vehicle

- Exporting defence products through LoC under Govt. of India and utilising
- EXIM bank opportunities.

The products planned for exports are Armour Personnel Carrier, Wheeled Armoured Vehicles, Armoured Recovery vehicles, HMV 6X6, HMV 8X8, Engineering Plant equipment (Dozers, Excavators, Motor Graders), Prime mover with trailer 20 & 50 ton, Heavy Recovery Vehicle and Aircraft Towing Tractors, Medium Bullet Proof Vehicle, Crash Fire Tenders.

VAYU : Could you shed some light onto the indigenisation efforts of BEML? What are the indigenisation levels in various divisions?

BEML: BEML has made considerable efforts during the last few years to indigenise large number of imported parts across all the three business verticals under Atmanirbharatha. Around 1400 parts have been identified for indigenisation over a period of five years and same have been uploaded in SRIJAN Portal for indigenisation.

BEML has indigenised the products manufactured under license and technology transfer agreements through extensive R&D efforts and achieved over 90% indigenisation level on most of mining and construction products, over 80% on defence and aerospace products and over 60% on metro and rail products.

BEML recognises outsourcing as one of the strategic tools to achieve cost benefits and also complement the strengths of private sector to build a strong industrial base. BEML has established itself as a system integrator by outsourcing substantial part of manufacturing activities to domestic suppliers.

Further, BEML has indigenously developed and manufactured various equipment by involving Indian private industries such as Arjun Armoured Recovery & Repair Vehicle (Arjun ARRV), Medium Bullet Proof Vehicle (MBPV), Vehicles for Mounted Gun System (MGS) Dhanush, Vehicles for Mounted Gun System (MGS) with AK630, AI based Medical Health Care Diagnostics System (MHDS), Mobile Stand by command post vehicle (MSCPV) on 4x2 chassis, Sarvatra Bridge System, 10 mtr and 5 mtr Short Span Bridge System, Mine Field Marking Equipment (MFME), Mechanical Munition Self Propelled (MMLSP), India's biggest high-end Dump Trucks of 150 ton and 190 ton, India's biggest high-end Excavator of 180T and also Unmanned Train Operation (Driverless) Metro Rolling Stock.

VAYU: BEML recently signed a MoU with RITES Limited to explore opportunities in the field of Rail and Metro systems and export of rolling stock. Could you share the details?

BEML: The parties intend to synergise their efforts by complimenting their respective strengths for marketing, supply and services for Rail and Metro products including rolling stock manufactured by BEML in domestic as well as in overseas market.The duration of MoU is for 3 Years. Our role is to manufacture and supply rolling stock and spare parts and to provide technical and service support. RITES role is to provide design engineering, project management consultancy, marketing, O&M support and any other support that may be required.

Heavy Recovery Vehicle

VAYU : BEML offers a comprehensive and diverse range of mining machinery for both opencast and underground mines. What are the latest business operations in the sector?

BEML: The focus is on environment-friendly and safety technologies in the mining sector:

a) BEML launched in house designed electric hydraulic shovels in the range of 70, 100 and 175 ton class. These mining equipments are well accepted and run completely on high voltage electricity.
b) The rope shovels and walking dragline are completely driven by DC/AC electric systems and are used extensively in the mining sector.
c) BEML has launched hybrid dumpers suitable for mining application.
d) BEML has strategic plan to develop hybrid and electric/battery operated driven dozer, wheel loader.
e) BEML has launched CEV stage IV compliance motor grader and wheel loaders.
f) All the equipment meets the strict safety guidelines issued by DGMS and also meets the ISO and IS standards.

Some of the key safety features are: Acoustic cabin with <80dbA noise level, ROPS/FOPS cabin, mechanical anti-collision system for dumpers, operator fatigue monitoring system, 360° surround monitoring system, blind spot proximity warning system for dumpers, ABS braking system, air suspended operator seat, EMI/EMC compliant electronic devices and fire retardant wire harness and hydraulic hoses.

VAYU: How well does the rail and metro division of BEML perform? How do you intend to tap business opportunities in expanding metro rails in the country?

BEML: BEML at present hold market share of about 44% in terms of metro car supplies in the country. We note that the Government of India is putting great thrust on infrastructure spending including development of many Metros rail projects in future. As premier supplier of rolling stock to metro corporations in the country, BEML is at the forefront of adapting to the latest technologies and expanding its expertise and capacities as well as strengthening its supply chains to cater to the substantial emerging market requirement. BEML is also looking for partnerships to address


Medical Health Diagnostic System

new product categories in Indian urban rail transport such as LRTs/Trams/High Speed trains etc. We hope BEML will continue its dominant position in Indian metro rolling stock market in the future.

VAYU : BEML organised a seven-day exhibition 'Journey of BEML Since 1964' showcasing its capabilities in both defence and non-defence segments. How successful has the expo been and what were the highlights?

BEML: During the week of 13-19 December 2021, BEML Limited celebrated Azadi Ka Amrit Mahotsav across all its manufacturing Units i.e. Bengaluru, Mysuru, Kolar Gold Fields and Palakkad. An exhibition was organised to showcase the 'BEML's Journey since 1964'. The exhibition was inaugurated by the Defence Minister. We showcased our major equipment and aggregates during the exhibition.

Arrangements were made for pickup and drop of school students. Wide media coverage was also imparted for citizens to witness the prowess of BEML equipment. Necessary arrangements were made for all visitors. All senior officials also visited and encouraged visitors. We are happy to share that during the period the footfall was around 22,000 visitors.

VAYU : BEML paid a dividend of Rs. 13.50 crs to the government. How strong is the order book of the company and what all operations decide the profits?

BEML: The order book is around Rs. 9500 Crs. Profitability is dependent on the product mix and all verticals combined.

VAYU : It has been less than a year since you assumed charge as the CMD. How do you assess the operations of BEML and what are the objectives ahead?

BEML: My vision for the Company is to become a cornerstone for India's Make-in-India aspirations, a manufacturing hub for the highly competitive core businesses. Immediate priorities will be to leverage the strengths in our core business for significant growth in the next 4-5 years. This would involve diversifying in the aerospace and defence business, accelerate the growth in rail and metro business and sustain the mining and construction business. We need to develop new products adopting the latest technologies through strategic tie-ups with global players and premium academic institutions. Increasing the indigenisation levels in all the products will be a key thrust area. Exploring the international market opportunities in all the business areas to increase the exports will be a major priority.

The goal in the next few years would be to increase the revenues substantially with reasonable margins and contribute significantly towards exports.


Mine Field Marking Equipment (MFME)

BH150E Dump truck

Mettle of Metal

Land 400 Phase 3 Trial (Australian MoD)

Frankly, now you might be getting an interesting insight on Russian armoured operations in Ukraine. The unarguably dismissal performance in the ongoing conflict , all those anti-tank weapons used against Russian thrust, the tactics used by the Ukrainian resistance to stop Russian advancement and the questions regarding Russian quality - wouldn't they make an interesting subject? But the Editor said, "Hold on! The glasses are untidy, let the fog of war be cleared of all falsehood, never ever rush in along with the crowd making mistakes". So holding that review for the future and instead here's a piece on the best infantry fighting vehicles around the world you must know about! Honesty, this was a pure joy to work on and hopefully you will feel the same while going through it.

AS21 Redback

It's a great feeling to start the list of best with an Asian product which is competing against Western counterparts around the world. Redback is a new generation combat platform developed by Hanwha Defence of South Korea. First unveiled at ADEX 2019, since then the advanced features has sent both the experts and enthusiast alike into a tizzy. A high mobile platform provides superior protection against ballistic attack, mines/IED as well as protection against the chemical, biological, radiological and nuclear (CBRN) threats. With the help of add-on armour, the protection level can be enhanced to STANAG Lebel 6. In Australia this opportunity is provided by Plasan. Redback can be integrated with Elbit COPAS or EOS ICSS. IronVision provides a 360° situational awareness. Hanwha is now offering a new Redback turret for AS21 demonstrated in Australia. It is equipped with Mk 44S 30/40 mm auto-cannon, Spike LR2 ATGM (anti-tank guided missile), and 7.62 mm EOS R400S-Mk2 RCWS (remote controlled weapon system). Iron Fist APS (active protection system) provides protection against HEAT (high explosive anti-tank) rounds as found in RPG (rocket propelled grenade) weapons as well as in ATGM. According to reports, it can be offered with EOS T2000 turret as well. Redback is powered by MTU MT 881 engine with an output of 1090 hp. Doosan Mottrol in-arm equips the hydropneumatic suspension. Soucy Defense provides the composite rubber track which helps in smoother and quieter mobility. In fact most of all the other platforms mentioned in the article will use the same kind of add-ons if not equipped with them already.

AS21 Redback (Image: Hanwha Defense)

KF41 Lynx

It is a German armoured fighting platform developed by Rheinmetall Landsysteme and a further improvement of earlier KF31. The 40T platform offers high degree of customisation for adequate firepower according to the need of the customer - from older LANCE turret to the improved LANCE 2.0. The LANCE 2.0 can be equipped with 30/35 mm auto-cannon as well as a 50 mm gun. For additional performances MSSA or Field Ranger RCWS (remote controlled weapon system) and Spike LR2 ATGM can be added. Recently a new variant Lynx 120 has been developed for fire support. It is equipped with 120 mm smoothbore gun. The gun is shorter for better urban/jungle warfare capability. Lynx now is being offered with three different APS for different customers - Quick Kill 2.0, StrikeShield and Iron Fist. This proves high level of customisation which is the need of hour in the rapidly changing environment. Rheinmetall SEOSS (Stabilised Electro-Optical Sighting System), LWR (laser warning receiver), situational awareness etc provides the ISTAR (Intelligence, Surveillance, Target Acquisition, Reconnaissance) capability enhancing the performance by multifold against the potential adversary. For OMFV programme in the US, next generation electro-optical systems from Raytheon will be added. The excellent mobility is maintained by the Liebherr D976 1072 hp engine (debatable) and Renk transmission.

KF41 Lynx (Image: Wikipedia)

B-11

Kurganets-25 is the latest combat vehicle from Russia which offers extensive protection, high firepower, excellent mobility and situational awareness. As a member of the Armata Universal Combat Platform family it shares some technologies found in the T-14 Main Battle Tank. Depending on the need, this platform can be customised for both infantry fighting as well as an armoured personnel carrier. The IFV variant is known as B-11. It has new generation optics and electro-optical target acquisition system for better combat prowess. The Epoch combat module carries the same 2A42 30 mm auto-cannon but thanks to new fire control system it can achieve an enhanced performance. But it can be replaced with 57 mm LShO-57 cannon if needed. It carries a RCWS and Bulat RU grenade launcher. For anti-tank role it carries four Kornet EM ATGM. The Monolit explosive reactive armour (ERA) is expected to give protection against HEAT. Further enhancing the protection, Afghanit APS has been added. Despite so many advanced features it weighs just 25T and thus it can be deployed for amphibious operations as well. With the help of 800 hp engine it can achieve an excellent mobility. This system is still under trials.

Ajax

Ajax has been developed for the British Army by the General Dynamics UK. The chassis is based on proven ASCOD 2, which has further led to development of Griffin III hull. However, necessary changes have brought in for enhanced protection without compromising mobility. Thales ORION or SAFRAN Paseo sights can be integrated for Commander and Gunner application. In case of the British Army, for better interoperability Thales ORION independent panoramic sight is used in Challenger 3 as well. Thales LSA (local situational awareness) provides a 360° surveillance capability. Thales

Ajax (Image: Wikipedia)

Acusonic acoustic shot detection system can detect direction of enemy fire. Thus Ajax has a robust capability to dominate the battlefield with enhanced awareness. It carries Nexter-BAE consortium CT40 cased telescoped armament system fitted to a turret developed by Rheinmetall. LWR and 76 mm smoke grenades help in risk mitigation against enemy anti-tank missile attack. It is expected Morpheus C4I system will provide interoperability with Challenger 3 and other platforms. MTU TE21 engine can create more than 800 hp power. But in spite of so many advanced features the Ajax is mired with many problems. The most serious one is the excessive noise and vibration leading the crew towards hearing impairment, tinnitus, nausea and joint swelling. Besides, question arises on its mobility as well, particularly while crossing the obstacles running backwards. The future armoured fighting capability of the British Army relies on three programmes- Challenger 3, Boxer and Ajax. However, without any clear vision to resolve the Ajax issues the capabilities might be compromised seriously.

Puma

Puma is another modern infantry fighting vehicle from Germany incorporated with cutting edge technology and developed by Krauss-Maffei Wegmann (KMW) and Rheinmetall. It was developed to replace ageing Marder platform. The RWM 30 mm MK 30-2/ABM acts as the main armament along with secondary HK 5.57 mm MG4. Puma offers a dynamic protection with the appliqué AMAP (Advanced Modular Armour Protection) against KE strike. For enhanced protection MUSS (Multifunktionales Selbstschutz-System) soft-kill active protection system has been added. MUSS has an infrared jammer, MILDS UV missile warning sensor, laser warning receiver and smoke grenade dispenser. MTU-Renk duo provides an excellent power pack of more than 1000 hp. Recently, a contract has been signed to upgrade and retrofit 154 Puma vehicles already in services with the Bundeswehr. Some of the notable features are new optics for driver, commander and gunner for better situational awareness, a new turret independent system (TSWA) for critical situation, MELLS guided missile system to target the enemy at a distance of 5500 meters with Spike LR ATGM, new digital radios and integration of Future Soldier - Expanded System (IdZ-ES) and BMS.

CV90 Mk. IV

Combat Vehicle 90 is manufactured by BAE Systems AB of Sweden and Mk. IV is the latest development of it. The oldest of all in this list still can showcase its prowess as one of the best platforms around the world. It is also the sole warrior in the list seen combat experience. The gunners fire control system is provided by SAAB UTAAS (Universal Tank and Anti-Aircraft System) while LEMUR SW is the commander's independent sight. Elbit COAPS provides an independent 360 degree panoramic sight which is placed on a 500 mm extending mast allowing an enhanced observation in concealed position. It is equipped with D series turret which allows integration of 30/35/40/50 mm Bushmaster cannon and Twin Spike LR. It is equipped with Iron Fist active protection system as well. With the help of a low recoil 120 mm Rheinmetall

Puma (Image: Wikipedia)

CV90 Mk. IV (Image BAE Systems)

gun it can be used as a 45T medium tank. The change increases weight by almost 10T but Scania V8 1000 hp engine still provides a decent hp/t maintaining excellent mobility.

Bonus - Carmel

Often dubbed as a Gen5 fighting platform with integrated unmanned capability, substantial automation, sensor fusion, interconnected situational awareness and augmented reality, is originally a retrofitted M113! It is developed as a technology demonstrator for test of several cutting edge development. LIDAR radar for better target acquisition and 3-D mapping of battlefield, IronVision see through armour technology, STA Mk. II EO situational awareness and advanced optics for the crew together boosts a robust performance from the crew.

Major acquisition programmes around the world

US - Optionally Manned Fighting Vehicle (OMFV) is a highly ambitious programme to replace the Bradley platforms currently in services.

Possible OMFV contenders:

1) GDLS offering Griffin IV platform which will be equipped with ARDEC 50 mm gun from Orbital ATK.
2) American Rheinmetall along with Raytheon, Textron and L3Harris pitches KF41 Lynx with LANCE 2.0 turret.
3) Oshkosh and Hanwha to further develop AS21 and Samson turret.
4) BAE seems working on further revolution of next gen Bradley platform and will be equipped with Elbit UT 30 Mk. II.
5) Point Blank recently revealed their concept 'Liberty'. However not much known about this though some ideas can be derived about the turret and the main gun from the graphics published.

UK - The British Army plans to procure around 590 Ajax family vehicles replacing older CVR(T). But multiple issues have derailed the acquisition programme. Study is going on how to fix the problem.

India - Future Infantry Combat Vehicle (FICV): India released a RFI for the procurement of 1750 infantry combat vehicles and variants to replace ageing BMP-2.

Australia - LAND 400 Phase 3: After the US, UK and India, Australia has the largest acquisition programme. Through LAND 400 Phase 3, the Australian Department of Defence (DoD) envisages procurement of 450 new generation IFV and 17 manoeuvre support vehicles (MSV) at an estimated cost of $27 billion! Rheinmetall and Hanwha Defence have pitched their products. So, it's an AS21 vs KF41 show and in the trials they have performed toe to toe. When you will go through this article, a decision on this likely will have taken.

Czech Republic - requirement for 210 vehicles. CV90 Mk. IV, KF-41 and ASCOD 42 are contesting.

Slovakia - requirement for 152 platforms. CV 90 MkIV, Borsuk, ASCOD and KF 41 are participating.

All information is based on best credible sources and authenticity has been maintained as much as possible, but with new updates these likely to be changed.

What does this mean for India?

BAE, Hanwha Defence and Rheinmetall already have pitched their platforms and offered customisation according to the needs of the Indian Army. Many other OEM are expected to offer theirs as well. Multiple indigenous alternatives are also being developed in partnership with the international flag bearers in this field. A clearer picture might come out during the forthcoming Defence Expo (which has been postponed and delayed to an undeclared date). Whereas many of these above mentioned platforms are integrated with the best technologies currently available around the world that certainly does not mean it will meet all the requirements of the Indian Army. It will not be easy to provide an enhanced multi-layered protection, state of the art situational awareness, adequate firepower and excellent mobility without compromising amphibious capability. India will closely follow such acquisitions and development programmes around the world and then will decide through thorough calculations.

Sankalan Chattopadhyay
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Lessons from the Bekaa Valley - an Indian's assessment

By Prof. Prodyut Das

Introduction

The tale of the air war over the Bekaa Valley has only improved with time and telling. It was definitely a spectacular operation but various slanted lessons have been read of the operation, though the Israelis themselves have often said that its lessons cannot be generalised.

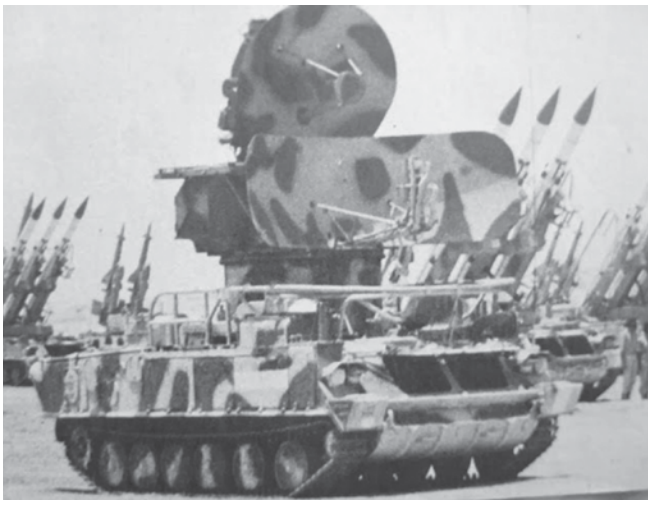
This assessment is based on a selection of typical analyses done by various agencies. I have based as my source official analyses by Col. Dubrov writing in the Aviytsiya and Kosmonautica on the lessons of the war and a commentary on the same by Dr. Benjamin Lambeth writing for RAND. Both these journals are "Government" and being Government has the merit of being true though, again being Government, not the whole truth. A factor none of the reports mention was the contribution of the terrain of the Bekaa Valley. The terrain of the Bekaa Valley was significant to the final results and makes the operation" unique" rather than "general". This has been discussed.

Military reports often have a strong "marketing" angle to them. The more obvious biases were filtered out. It then appears that at the Bekaa Valley rather than "the latest technology" (i.e. unaffordable) warplanes winning the war it was the traditional qualities- diligence, carefulness, training and planning which the Israelis displayed over a sustained period- a decade to be precise-paid rich dividends whilst dogged courage –which the Syrians displayed in abundance- did not get the Syrians anywhere. It should not be taken to mean that if the Syrians had the same qualities of careful planning as the Israelis the loss ratio would have been reversed but certainly the Syrians could have given the Israelis – who are poorly placed to take casualties- quite a bad fright. With equally careful planning and some supplementary low-cost upgrades on the part of the Syrians the Israelis could have been dissuaded from undertaking the operation at all which is the ultimate achievement of any Armed Force. As an aspirant but pacific major power with the usual budget constraints the major lesson for us is Bekaa Valley as a case study of how more economical alternatives are contrived and made available to us. Bekaa Valley needs an unbiased but intensive study.

Various claims and predictions have been made about the conflict from the Israelis having invented a secret weapon to the fact that the Bekaa Valley triggered the collapse of the Soviet Union to even that Bekaa Valley is a proof that third (read x) generation fighters cannot survive against fourth (read x+1) generation aircraft. This view needs reasoned debate in India because the assumption is less true than is generally supposed to be and we face the similar problem with China with its larger Industrial base.

For India the tactical lessons of the Bekaa Valley are not important. The IAF is more than up to that job. The focus is on the philosophy. The Israelis had numerical superiority both overall and locally. Ignoring numbers to concentrate on quality would be as sure a way to defeat *as to rely solely on numbers.* One of the important lessons of the Bekaa Valley- completely avoided by the "marketeers" of sophistication is the importance of adequate numbers of adequate rather than necessarily top end warplanes.

How to achieve this balance between sophistication and numbers should occupy our experts because the scenario is India specific and somewhat different from "world standards". No one- certainly not the vendors- will tell you what the specifications really should be. If you enjoyed the first Kung Fu Panda movie you will remember that the secret of the Magic Scroll was that there was no secret and no one will teach you any which way– you have to "figger" out the secret of the Wu Xi hold yourself!



SA-6's (Images Commons/Wikipedia)

The Yom Kippur War

The success at Bekaa rose from the graveyard of Yom Kippur. In the Yom Kippur War of 1973 the Isr.A.F. suffered horrendous losses to the new and then largely unknown SA-6. (Note 1) The flat Sinai terrain allowed the tracked launchers room for manoeuvre as well as presenting the aircraft as a clear high contrast target. The *flat launch* trajectory of the SA6 was also of no problem. Under ideal conditions for the SA-6 systems, it was devastatingly effective and the total Isr. AF losses in the critical first 72 hours was 50 aircraft (Israeli figures) and the total losses over the 18 days air war was 109 aircraft. How many fell to what system will not be known because amongst other things the Isr.A.F. mentions all losses as "operational loss" or, if they are feeling particularly talkative that day, "due to ground fire". As with the PAF, air to air losses were never acknowledged. Another noteworthy fact was that despite all the legends of Israeli prowess in Intel, lack of up to the minute information had repeatedly caught the Israelis flat footed in 1973. The final Israeli Victory was not only expensive for Israel it also underlined that Anwar Sadaat had made his Clauswitzian political point. Egypt was no pushover.

Surviving the near mortal losses, the Israelis prioritised three lessons.

i) **Tactics**: They focused on the development of tactics to neutralise the threat posed by the tracked SAMs. In this they were aided by the Americans who had a direct interest as NATO forces would encounter the same missile systems in case of hostilities with the USSR. By 1978 i.e. after about five years the Israelis cautiously declared that they had the measure of the SA-6 threat (Note 2). By May 1980 the Israelis were able to "field test" their solution under actual conditions when they destroyed two SA 9 launchers but waited patiently for another two years for a suitable opportunity both tactical and political.

ii) **Numbers**: Having lost about seven squadrons worth of aircraft written off in Yom Kippur i.e. half their Air Force they also built up their number of combat squadrons from 14 squadrons to 21 squadrons which included helicopters for the CAS role. It took the Israelis about 5 to 7 years because of the time to train new aircrews and reach an acceptable level of proficiency. The time required to build up of air strength is noteworthy because it is a period of vulnerability.

iii) **Intelligence:** Learning from their unpreparedness from Yom Kippur they reorganised their information gathering and dissemination system thoroughly so that information, even at the squadron level was real time. It is interesting to note in the reports how much stress the Israeli put on the "freshness" of the information. Without the latest information the Bekaa Valley operations would have unravelled badly!

Clockwise from top-left: Israeli tanks crossing the Suez Canal, Israeli Nesher variant of the Mirage V fighter jet flying over the Golan Heights, Israeli soldier praying in the Sinai Peninsula, Israeli troops evacuating wounded personnel, Egyptian troops raising the flag of Egypt at a former Israeli position in the Sinai Peninsula and Egyptian soldiers with a portrait of Anwar Sadat (Image: commons.wikimedia.org/wiki/)

The Bekaa Valley shootout

The details of the operations are widely available; what is given here is a summary. Syria had involved itself in Lebanon in support of the PLO and in the early 'eighties. It had moved its SA-6 batteries into the Bekaa Valley to protect its forces in Lebanon following the shooting down of two of its helicopters by Israeli F 15s. In June 1982 Israeli forces invaded Lebanon after informing Syria that they had no intentions against the Syrian forces and were after the PLO and would penetrate 40 kms into Lebanon. Syria accepted the conditions and moved its forces out of the way. When they exceeded that 40 kms limit the Israeli advance was halted by a Syrian armoured division at the River Jazzine on the night of 8-9 June 1982. Israel then saw that as a long-awaited opportunity for its

Egyptian military trucks cross a bridge laid over the Suez Canal on 7 October 1973, during the Yom Kippur War/October War (Wikimedia)

plan to take out the SA-6 batteries. The Israeli Armed Forces, now fully prepared to achieve its long-standing war aims was deliberately inexact about the excessive advance- 40 kms- from where had not been precisely defined-, emphasised to the Israeli Cabinet that taking out the SA-6 batteries was crucial to the safety of the Israeli armoured division under Syrian attack. They also assured the Israeli politicians that given its preparations, careful planning and homework its losses would be minimal. Political sanction was given by 1000 hrs of 9 June 1982 but the strike was postponed due weather conditions over Bekaa and the need to update information. The strike was finally unleashed on the SAM sites at around 1400hrs.

It will be noted by planners that despite the overwhelming superiority of the F 15/ F16s over the MiG 21SMT the Israelis waited patiently for another three-four years i.e. until all the other elements in their game were ready, before engaging in combat. The platform›s superiority is not everything as is sometimes propounded.

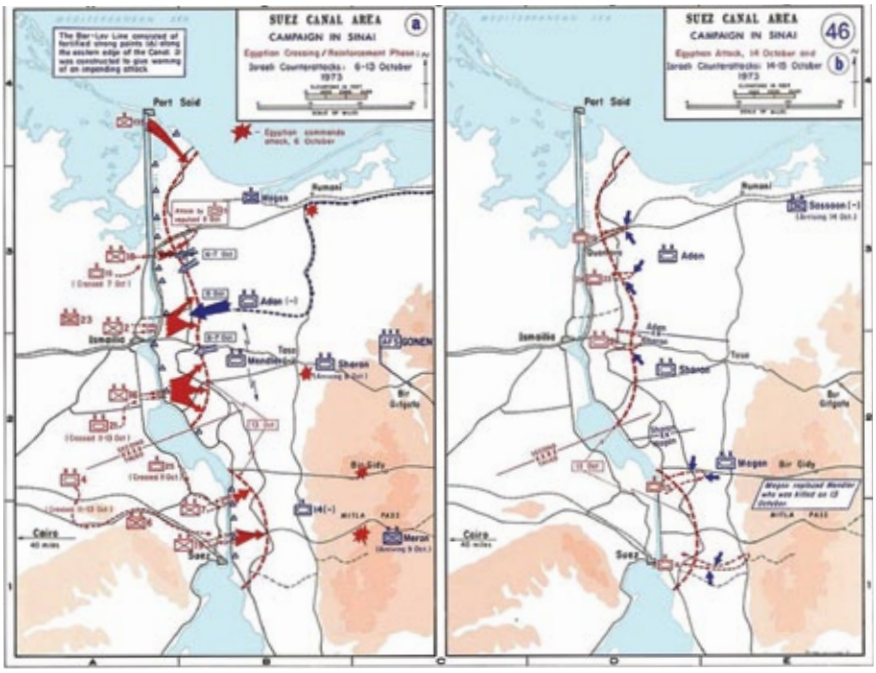
The strike consisted of aircraft at three levels. It will be of note to India that second generation airframes with upgraded avionics e.g. Kfirs/Nesher and upgraded Skyhawks were used and provided CAS at sea levels. Third generation aircraft, F4s, were stacked in "cab ranks" at 3000 mts and at 9000 mts were the Boeing "jamming" aircraft and the E2A's AWACS used to direct the strikes. The Syrians apparently withdrew their combat air patrols but by 1420 hrs the Israelis attacked the EW radar at Jebel Barick. The Syrians reacted with fighters about an hour later but were shot down flight by flight as they blundered blindly against the Israelis who could not only monitor, thanks partly to the use of IAI Scout UAVs, each flight almost as soon as they took off but also had jammed their communications.

At around 1550 the Israelis went in for the SA-6 sites using HARM, Shrike and similar standoff missiles mounted on F 4s. The F 16s and F 15s were not tied to close escorts but were employed in the "free hunt" mode with the F 15s also being used as mini AWACs to cover the gaps in coverage. As can be seen from the topographical map the Lebanon side of the Valley was blanked off from the Israeli AWACS by the Lebanon ridge as the E2s were operating out over the sea to avoid being shot down by Lebanon based SA-6s.

At its peak there were up to 90 Israeli and 60 Syrian aircraft (note the Israeli numerical superiority) in the conflict zone which was about 40kms by 40 kms. Having first "blinded" the guidance radars with ARMs the SA-6s were destroyed all by cluster bombs in a very short time- reputedly about 20 minutes because of the up to the minute knowledge of the SA-6 positions. Noteworthy was the fact that LGBS were not used because the Israelis deemed them to be too slow. It is also noteworthy that the Israelis used long ranged artillery, the Zeev, as an economical way of knocking out the Syrians SA-6s that were within its range. The use of "smart shells" has also been mentioned.

The Losses

The figures usually quoted for the Bekaa Valley shootout are about 85 to 87 Syrian aircraft shot down for no losses for the Israelis. These figures, as with the



The 1973 War in the Sinai, October 6–15 (USMA Department of History/Wikimedia)

Soviet official figure of 60 Israeli losses, must be taken as untrue and for respective domestic consumptions. The history of estimation of air combat losses shows that the enemy's losses are always difficult to estimate even given the best of intentions and intentions are not always the best. In the Battle of Britain the RAF claimed destroying 178 Luftwaffe aircraft on an occasion when the actual German losses were 45. So what were the actual losses?

Overclaiming is common. Since the fighting was taking place over territory that was Syrian held it would be difficult to verify the Israeli claims. The Syrian admission of 50 losses and 18 pilots (Note 3) are likely to be nearer to the truth.

The Israeli losses are – and I am going only by my readings on the subject - would have been around ten to twelve. Of these three, two A4s and a Phantom F4 have been confirmed by photographs of the wreckages and the rest must have been caused by the formidable AAA at Bekaa Valley. Whatever their lacunae in terms of planning, the Syrians did not lack in bravery and "stuck to their guns" (literally!) and it would be incredible that the "dumber" weapons 2X23 and 4X23 mm AAA did not "damage beyond economical repair" (delightful PAF phrase; note 4) This is not to belittle the Isr.A.F achievement because 50 kills for wastage of 12 aircraft i.e. 4:1 is enviable.

An analysis of the results

The Bekaa Valley shootout has been used to sell everything from the "latest and best" fighters to, I am fairly sure, some variety of malted milk drinks! There is a view that Bekaa Valley confirms that "quality" will triumph over "quantity". Even in India the Bekaa Valley was fairly recently cited by the then Air Chief to stress the need for quality.

My conclusions are somewhat different**.** Bekaa Valley confirmed more than anything else the traditional qualities of military planning- a mastery of one's own weapons and a thorough knowledge of the enemies', careful planning, patience, and numerical superiority (to be noted, please, that the Israelis had very significant numerical superiority!), training all played apart. The element of surprise and the first mover's advantage-which is always significant is also to be noted but, in this case, inexcusable on the part of the Syrians. They had, as we in 1962, had years of warning. The Bekaa Valley shoot out was an aerial commando raid brilliantly choreographed. Thanks to diligent planning when it came to the actual fighting, the Israelis were shooting fish in a barrel. Below are some salient points we should note:

The terrain

None of the analysis above mentions anything about the terrain. One can conclude it played no part but this goes against common sense if you look at the contours of the Bekaa. A topographic map of the Bekaa Valley by the geologist A.S.A. Lateef is included and shows the contours. The Bekaa is a rift valley with two ridges rising to peaks of 2800 mts and a gap of around 16 to 40 kilometres between the ridges. The map does not show the ridges to full height which were fairly narrow at the top precluding SA-6 mobility critically. The North - South orientation of the ridges meant that the theatre was isolated into three sectors- Lebanon to left, Bekaa in the middle and Syria to the right of the ridges. Any radar located in any of the sectors were isolated by the ridges from

Image by Israel National Library. Photographer As Subject: Nathan Fendrich during a relatively calm moment during the 1973 Yom Kippur war

looking into or networking with the other two areas and those located on the ridges were sacrificing their mobility and siting options. The Isr.AF EW stations could look up and into the valley. The fighting was confined to a very small "bowl". What advantages it gave to the jamming which was a big contribution to the success or how the opposite ridge wall may have disadvantaged the SA-6s tracking radars clutter suppression abilities –something that was never a problem in the Yom Kippur War- cannot be quantified here. It must have been a significant factor never mentioned in the reports.

The Distances

A second feature was the relatively short distances of the airbases of both the combatants from the Bekaa Valley. Typically, they would be within 80 to a 100n.m. of the Bekaa the Israelis could loiter over the battle area and were able to give instant support where ever needed.

AWACS

The Israelis were using at least two of their four E2 Hawkeyes and these were operating well above the battle at around 9000 mts and 20 kms away from the Lebanon coastline to stay out of Syrian SAMs on the seaward side looking right down into the arena. This was supplemented by the powerful radars of the F 15 which supplemented any "blind spots"- a strip about 6 kms wide caused by the shadow of the Lebanon side ridge to the E2's radars out over the sea. The Israeli set up and maintained an imaginary threat line on the Syrian side and any Syrian flight that crossed that line was destroyed, the Israelis sending in their forces so that there was no friendly fire.

The missiles

The Israelis used the AIM7F Sparrow, the AIM 9L Sidewinder. The homegrown Shafrir is mentioned but this could be a marketing effort same as the claimed PAFs use of JF 17s post Balakot. All the IR missiles were capable of "head on" attacks. The Syrians were using the Atoll which had very restricted launch parameters. The differences in the missiles were at least as important, possibly more a factor than the differences in the platforms.

The Syrian mistakes

The SA-6s mobility was a part of its repertoire for survival even if it was only frantic searching by the attacking pilot around its last known position. Using it on the ridges of the Lebanon (Jabil *al* Liban) and Anti Lebanon (Jabil *al ash* Shariki) mountains meant that mobility was severely compromised. The SA-6s were literally "sitting ducks". The Israelis knew exactly which holes to ferret and accounts for the swift destruction (allegedly 20 minutes for the 19 batteries) of the SA-6 batteries. Indeed, having suffered from the SA-6 in the Yom Kippur war the Israelis treated the SA-6 with informed respect, delaying at the last minute their strike until two batteries which had moved around a village were located.

When "baited" by flights of IAI drones the Syrians reportedly switched on all their radars thus revealing their position and confirming them to the ELINT aircraft. This sounds something out of Leon Uris "Exodus" but if true the Syrians deserved what they got.

MiG 21 SMT avionics

It is fair to describe the MiG 21 SMT as a third generation (Mach 2) airframe with a second-generation avionics' suite. The MiG 21's had only front and tail warning from its Sirena RWR and the Israelis who were dominating the agenda fed in its fighter streams to make beam attacks so the Syrians had no inkling that they were being painted even just prior to a VFR attack.

Image by Israel National Library. Tank In The Desert: A scene from the 1973 Yom Kippur War as photographed by Nathan Fendrich.

Jamming

The jamming of communications completely disrupted and demoralised the Syrian efforts. It was possibly the key force multiplier in blunting the Syrian response as the pilots were cut off from their GCI. In desperation they were seen to fly around in figure of eights trying to obtain visual contact until they were shot down. "It would not have mattered what aircraft they were flying because the way they were flying they would have been shot down anyway" said one Isr.A.F. senior planner. This statement is noteworthy. It is possible the confined spaces in which the battle was going on would mean that the jamming would have been particularly effective- the valley acting as a bowl antenna and also the short distances between the arena and the jammer was a factor- as a thumb rules the jamming declines as the square of the distance. It is interesting that the Israelis also used helicopter borne and ground-based jammers to ensure complete jamming. The ground-based jammers must have been particularly cost effective.

Jamming of attacks is nothing new. The RAF used "Headache" which was simply a microphone in the engine nacelle of the bomber and broadcasting on the frequency of the Luftwaffe's fighter control frequency. Very soon the Luftwaffe rigged up a simple device which would home onto the jamming i.e. they would fly to where the jamming was the strongest. Homing on the jamming Boeing 707s did not require high technology. It could have been rigged up by the Syrians themselves for their MiG-21s and would have passed the initiative of the battle over to the Syrians because the Israelis would have to move to protect the foundation of its attack strategy, the Boeing 707 jammer. Indeed, the Israelis used two F 15s as close escorts to protect it "Jammer" at all times. The Syrians should have anticipated heavy jamming/ other ECMs once the Hey A'vir got the Boeings and the E2s but obviously they did not. They paid the price.

Politics

In 1981 the COAS Maj.General Mamdouh Hamdi Abazi was assassinated by the Moslem Brotherhood. The Syrian Air Force had to be purged in early 1982. As with Stalin's purges of the Soviet Armed Forces it must have crippled the Sy.A.F. yet the reports do not mention this significant factor.

Lessons for India

The lessons for India are somewhat different than the tactical lessons discussed above. The lesson for us is the need for numbers. Since numbers are expensive a balance must be struck between unit costs and numbers. The second lesson, a corollary of the first, is that with more "thinking" on the part of the Syrians and with small upgrades to their equipment, as it existed, the Syrians could have got much better results to the point of dissuading the Israelis from embarking on a shooting war a problem we face with China.

Regarding numbers the Russo Japanese War of 1903-4 threw up all the lessons that mechanisation of slaughter made possible by the Maxim Machine gun. These were ignored and so had to be grimly re-learnt at greater cost in the First World War. The Yom Kippur and Bekaa Valley certainly and even Kargil and the recent post Balakot episode are microcosms of the losses that modern technology can cause.

Our primary lesson is to acquire the ability to absorb the horrendous losses we will suffer in the opening phases of any serious/sustained conflict with China. The need is to stay in the fight after the initial shock so that we can "give it back". Our ability to "Give it back" after the shock and not the initial losses will be the decider. The estimates could be anything between 80 to a 100 aircraft lost due to all causes and another 100-200 damaged to various degrees in the first 96-120 hours before we could come up with the counter tactics.

This loss rate means that of the ten to twelve squadrons will have been worse than decimated. They will need replenishment and, possibly, rotation. We need a larger air Force with the 50 squadrons along with a first- rate aircraft damage repair capability. Fifty squadrons are not just a round "Parkinson"-ian figure but the vital second- strike capability and therefore the position at the negotiating table. It is ironic that given the meagre vital assets of India in 1960 we had a 20 combat squadron Air Force. Even the archaic figure of 42 squadrons will not be sufficient because of the increased "mechanisation of the killing" since the 42-squadron figure was accepted. The inevitable sacrifice of the aircrew will have gone in vain if just as the attacker's first mover's advantage will have been evened out, we cannot hit back because of depleted strike strength. Ideally, we should have the latest and the best equipment for these fifty squadrons but the economy cannot sustain that. We would financially "Pakistan" ourselves very easily. We have to think alternatively regarding our technical specifications balancing quantity with quality.

It will be noted that the Bekaa Valley ended on the third days by a US/USSR sponsored cease fire before Syrian counter strategies, if any, could be brought into play. We must have sufficient political strength to resist such an enforced ceasefire so that the enemy can at least learn for the future.

We are therefore facing a choice about how we are going to be inadequately prepared. Either we have a small excellently equipped and trained air force that will be very sensitive to losses or we will have a larger well equipped Air Force but whose training and serviceability may suffer. The lifetime cost of equipment is usually three to four times the procurement cost. What we are trying to make at home is "not quite international standards" uncertain and delayed and what we import is unaffordable in the quantities we shall need and more important, unreliable politically. The problem appears at first sight, insoluble.

However, within the convolutions of the Bekaa Valley lies our answer. The solution will be to have a large force of "work maid" aeroplanes of a very well thought out rather than lavish capabilities. In defence of this line of approach it will be noted that:

i) None of the platforms used their "limits of the aerodynamic performance" limits. No one pulled 9G and more importantly none of the two hundred aeroplanes went supersonic let alone Mach 2. The Balakot fight reconfirmed this aspect as did Kargil.

ii) Equipment did not perform according to the brochure. A considerable amount of what we buy does not deliver. The "all weather" equipment did not perform under all weather conditions e.g. strikes had to be postponed according to the weather. If this was the case in the Mediterranean how much worse they will behave under Indian Monsoon/Aandhi. More generally every line of the marketing brochure is followed by several lines of fine print. We either read every line carefully or live in a fool's paradise.

iii) Very little additional equipment was needed by the Syrians to avoid the one- sided drubbing.

iv) The platforms by themselves were not important to the result as the Israelis themselves acknowledged. For example the Israelis did not rush in as soon as they had the F 15s/F16s platforms.

We have to game the problem differently and so asymetrise the war and look at the desired combat results in terms of the desired political aims. They did not have to win or shoot down more etc. The key analysis is to find what did they need so that the Israelis would look at their potential losses and perhaps be dissuaded from attacking? We have to ask ourselves what minimum the Syrians really needed to have evened out the losses substantially.

The Syrians did not need too much. Let me expand the idea:

I am putting a deliberately provocative proposal. Suppose "the Syrians" had a platform with the performance capabilities of the MiG 17/ Mig 19 in terms of top speed, high AoA, etc i.e something between a second and a third- generation airframe. There would be zero improvement i.e. the losses would the same as the "better" MiG 21 "the Syrians" used but the force would have been cheaper to buy and maintain!

To that add jam proof communications. Would the kill ratio have improved? By how much?

Suppose the Syrians then had added an "all aspect" rather than "front and rear" RWR system they actually had. This could have saved them from being blind in the cases of gun/CCM attacks. The scores would have been altered. By how much?

Then add to that all aspect CCMs the R 73/R60 or equivalent -what then? There would have been considerable change in the Israeli loss rates?

Now put in a HMDS- not the latest thing with this year's almanac incorporated in it -but something simple that can be locally produced and got into service and what will enable the missile to be pointed correctly. What would have been the kill ratio picture?

We see that fairly simple upgrades- All aspect RWR, better CCMs, HMDS could have made the MiG 17/ MiG 19 / hypothetical simple platform quite a deterrent. We also see that at a certain point the Israeli losses may have reached an "unacceptable" level. The question is at what point of this build up would "the Israelis" think carefully and twice before they would attack? They may still have shot down more Syrians but only with "unacceptable" losses.

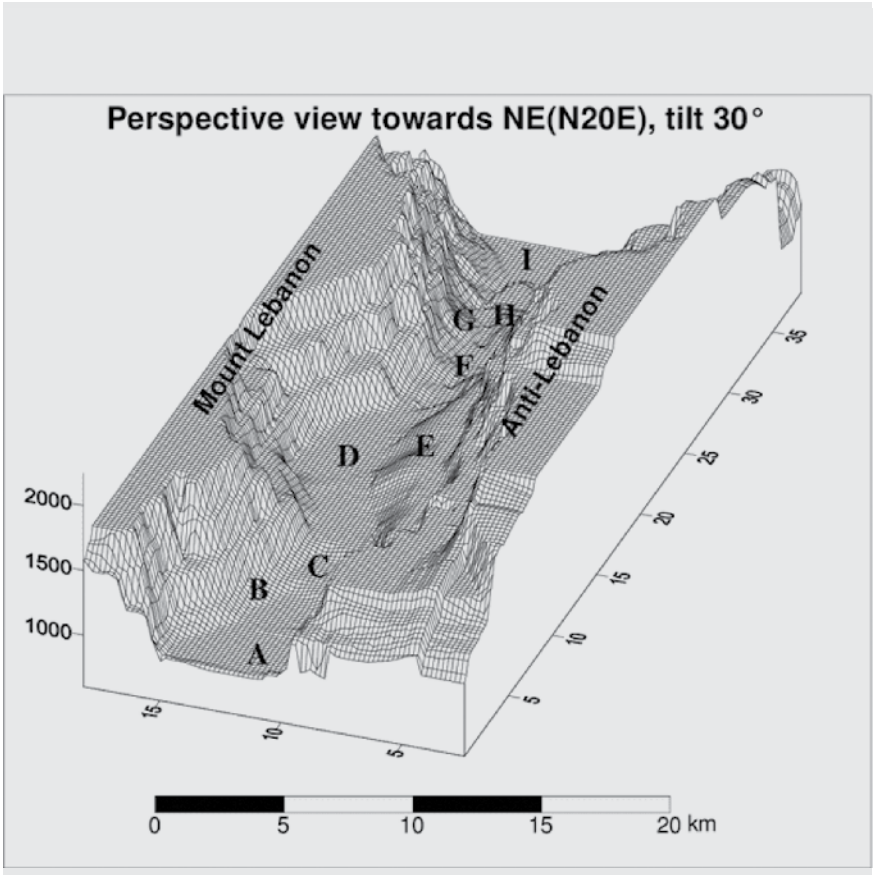
The basic gaming is what better minimum equipment and tactics should "the Syrians" have used so that the kill/loss ratio became unacceptable to "the Israelis". I emphasise the minimum. I have put "the Syrians" within inverted commas because as regards equipment specifications and fleet strengths "the Syrians" could be us in a future conflict. We are still relying on imported supplies and specifying what is available "off the shelf" and further crippling ourselves by a defective production and development system.

Soon we will get a picture of a relatively simple "minimum" aircraft tailor made for a clear well defined threat scenario –like ours- which is within the reach of our industry and costing a fraction of a Mach 2 all singing all dancing type. We start with what we can do for sure- and it is a fair lot- and then build up rather than match the sales brochure of the vendors line for line.

This is a "zero based" specification for a fighter general combat type which will form the core of our air power. The alternative is to import with the consequent options of a small- casualty sensitive air force or inadequately trained one. Please refer to the items 7 to 10 in the references list. We have chosen a very wise mix of MKI/ MMRCA/ LWF aircraft to meet our air defence needs. We must maximise the flexibility and the economies this mix gives us to get the large air force that we need but cannot afford if we rely on import.

In Sum

To use the Bekaa Valley as a justification for unaffordable equipment as commonly done is certainly flawed. The Bekaa Valley Air Operations was an unique commando operation: violent, effective but unlikely to be repeated. The real lesson is that



"Technology" is not decisively everything. "Bekaa" could have been" won" by the Syrians even with the same "hand". It was possible for the Syrians to have done much better and foiled the Israelis with greater losses which would have been good enough. The reasons for not doing so will never be known but it would have been relatively easy for the Syrians to organise. Perhaps for the highly politicised Arab Armed forces and the purges of the small (6-8 squadrons?) Syrian Air Force underwent just prior to Bekaa this was not possible.

The real lesson for us is the likelihood of severe losses for the "defence" and how to absorb them and still remain in the ring. We need a large and sensibly equipped Air Force rather than one to the highest international standards. For us we have to consider whether, with all due respects, is our thinking being "jammed" by Western concepts? For us following their doctrines is sure recipe for being underprepared and yet we need those fifty squadrons and I believe with a more efficient, less Leftist doctrinaire structured industry, a fifty squadron Air Force is affordable.

Appendix 1

The changing game

Guided weapons and AI are putting the onus of performance on the missiles and the aircraft is continuing to be more of a platform than ever before. The West, having developed the Mach 2 platforms some sixty years ago, are continuing to use them as the basis for their future aircraft but there is no need for Mach 2 or even Mach 1.4. It is a half-truth that transonic performance is "better" in a Mach 2 airframe. It need not be so.

We have to evolve a comprehensive doctrine to see how we can cobble a credible deterrence to any threat using whatever technologies that we have developed e.g. the LCA with more range and better transonic handling rather than overpowering it with an engine technology that we still do not have to reach the Mach 1.6 speed and super cruise which is nice to have but which we do not need. Show me the scenario where imported "supercruise" outweighs being dependant on imports.

I insist on the transonic regime i.e. around and less than Mach 1.3 because aircraft in that regime can be significantly smaller, longer ranging and cheaper than something even at Mach 1.4- Mach 1.5 and what is more completely within our present technological capability including the required engine technology. I do not believe that we will get any engine technology by any collaboration. Even if we did we would not know what to do with it because the "know why" of this nature cannot be taught. "Know why" is situation specific. Our needs and situations will not match theirs.

Having selected the correct "three class" fighter formula the whole will unravel unless we make the LCA type the cornerstone of our numbers the 30 or 35 squadrons of Fighter –General Purpose to work with the MKIs and the MMRCA s. This would be a transonic airframe with reduced radar (not full stealth- because it is beyond us, the performance penalty is too much and full stealth is probably a May laurel- it won't outlast May!) and IR signatures but with fifth or sixth generation information and display systems and using homegrown VFR missile systems and operating under AWACS and ADGES an area in which we seem to have made hopeful progress.

Note 1: These included actual firing tests in the Negev Desert on captured SA-6 systems.

Note 2: Each Syrian SA-6 battery consisted of one "Straight Flush" fire control radar, four SA-6 launchers based on the PT 76/ZSU 23-4 chassis each with three missiles and two ZiL 131-6 six wheel re- supply trucks. The batteries are controlled by "Long Track" surveillance radar and a thin Skin height fining radar.

Note 3: Of the 87 Syrian losses claimed by the Isr.A.F., 40 were claimed by the F 15s and 44 were claimed by the F 16s and one fell to a F 4. Interestingly the ratio of gun fire /CCMs kills are contradicted by the Israeli sources themselves possibly as a matter of policy. One source said only about 7% of the Syrians fell to the guns i.e. about 6-7 aircraft whereas another sources rather equivocally talked of "surprisingly large number of gun kills." Take your pick. Amongst the 17 Syrian pilots lost was their Ace of Aces Major Bassam Hamshu (8 kills including one on the ground in 1973) and Col. Fayaz Mansour (4 kills) who was shot down in a" friendly fire "incident by a Syrian tank using its 12.7 mm AAA.

Note 4: In his epic fight over Kalaikunda on 6 September 1965 Flt Lt Alfred Tyrone Cooke, IAF shot down one F 86 F and severely damaged "beyond economical repair" another F 86 F. He also holed two other Sabres but unfortunately was using "ball" ammunition rather than the more correct H.E. ("Minen") shell possibly due to supply and stock problems. Had Cooke been given the correct ammunition the 14 Squadron PAF would have another two Sabres missing or "beyond economical repairs". I mention this to emphasise that success will only come from planning and strategy at all levels and every detail. Equipment selection can be let down by non- supply at routine logistics level as was in this case.

References

1. Lambeth. Benjamin S "Moscow's lessons from the 1982 Lebanon Air War" 3000AI ISBN 0-8330-0587-1 September 1984
2. Duvrov V Colnel. Aviatsion in the Lebanon Conflict (Translated by Benjamin S Lambeth) *Aviatsiya I Kosmonautica* No 9 and No 10.
3. Grant. Rebecca "The Bekaa Valley Air War" Air Force Magazine 06/28/2008
4. Voronov. Vladimir The Syrian Nemesis. January 2017 (Translated Arch. Tait) Russia Studies Centre The henry Jackson Society
5. Flight International no 3832 16/10/1982 "The Bekaa Valley Combat.
6. Operation Mole Cricket 19 Wikepedia
7. Das. Prof. Prodyut Kumar " A cat amongst the pigeons" blogspot .com profprodyutdas and blogspot profprodyutdas2. Also in Vayu II/2016 "Flying against the wind" pp 86-93
8. Das Prof. Prodyut "The case for simpler Fighters" Vayu V/2009 pp 90-96
9. Das Prof. Prodyut "The Lessons from the Kaveri" Vayu/pp also above blogspot.
10. Das Prof. Prodyut Kumar" Falcon Griffon Tejas Vayu" 1/2017.
11. Nicolls David, Cooper Thomas Arab MiG 19 and MiG 21 units in combat Osprey Publishing 2004.

The contested airspace in South Asia

The war clouds forming over India and Pakistan are always a hot topic of discussion on various forums at the global level. Since the very inception of the two nations in the year 1947, the phenomenon of an arms race in South Asia always remained centric to these two states. Back in the phase of the Cold War, the top-notch types of equipment that were produced on both sides of the Iron Curtain always managed to find their place in this part of the globe as well. This is true in the field of Air Force which was filled with renowned solutions of air combat. It is noteworthy to realise that during the same period, the subcontinent arena saw two major conflicts, and aircraft designed by French, British, American, Chinese and Soviets were fielded on the frontlines and battle-tested up to their limits.

While in the past, generally each nation had its favorable partner, India with the Soviet Union and Pakistan with the United States, the modern-day weapon acquisitions by both nations are now promoted at a grand level, with manufacturers from both West and East entering the competition to secure orders for their products, some of them generally advertised as the "flagship" of their establishment. We are going to take a look at similar procurements of three jets which are backed by similar large-scale promotion and often asserted as "gamechanger" due to their ability to "turn the table" or the status quo established in terms of airpower strength and deterrence. We are going to analyse how well these newcomers, JF-17 Block III, J-10CE, and Rafale F3R offer their owners the lot and versatility that they seek to counter their respective adversary.

Rafale F3R(I): the French Falcon that dominates

The flagship of Dassault Aviation, Rafale came out on top in India after competing with some of the most excellent and battle-proven fighters produced by renowned aerospace giants. The 36 fighters were distributed among two squadrons of the Indian Air Force, which are No.17 "Golden Arrows" and No.101 "Falcons", are no less than an attraction for not just spotters but analysts around the world as well. The twin-engine canard delta-wing aircraft, in one line, is an "Omni-role" fighter that can be summarised in the form of capability that allows the Air Force to deploy the aircraft for multiple mission profiles in the same sortie. This is not often advisable for standard multirole fighters considering it requires compatibility of the mission computer onboard the aircraft to be optimised as per the flexible mission demands, that is from switching to between roles of air-to-air, air-to-ground, anti-ship or more. Though not referenced much often on mainstream, this capability is best

Photo: IAF

defined with the term "swing-role" where the aircraft is suitable to undertake the omnirole configuration for operations and "swing" or "switch" to the role to survive in the given scenario.

The composite airframe that is coated with a sufficient amount of radar absorbent material, packs within itself a state-of-the-art avionics suite. The aircraft carries Thales RBE-2AA Active Electronically Scanned Array (AESA) radar. As per Deagel, the system can detect airborne targets with 1-meter square Radar Cross Section (RCS) at 130 km. Standard fighter aircraft of the fourth generation or lower with standard weapons stores always exceed 3-meter square RCS that may make them vulnerable to RBE-2AA, as they are likely to be tracked within 160 km envelope. The radar is best used when cued with MBDA Meteor. This air-to-air missile is powered by a Solid Fuel Ducted Ramjet Engine (SFDR) engine that is known for utilising some of the most lethal tactics to hit its respective target. Ramjet is different from conventional rocket motors in the tactics where it utilises controlled thrust that can be triggered mid-flight as well as in terminal phase (when missile's own seeker turns active or locks on the target), that gives enough speed to prohibit the hostile to take evasive actions, especially when under the envelope of No-Escape Zone of Meteor, that is where it has max inertia and speed to catch its target.

To ensure that aircraft must not rely on the primary radar for combat, the Front Sector Optronics (FSO) integrated just ahead the canopy offers a great solution to target detection and identification in the IR spectrum, which makes sure that aircraft does not go handicapped in a strong radar jamming environment and adapt to the situation by employing passive modes of combat. The pilot can keep track of the targets with high-resolution imagery on one of its Multi-Functional Display (MFD) and also engage the target with CCM. The close combat capability of the fighter deserves recognition as well. The short-to-medium range MICA EM (Active Radar Homing) and MICA IR (Imaging InfraRed homing) missiles, when coupled with pilots' Display And Sight Helmet (DASH) offer great angles-of-attack in slow-speed dogfights, and matches with the great maneuverability, supported by canard delta wing design and high thrust-to-weight ratio (T/W).

It would be unfair if we miss Rafale's most lucrative highlight, its full-package Countermeasures suite SPECTRA. Standing for "Self-Protection Equipment Countering Threats to Rafale Aircraft", the system is designed to greatly enhance the aircraft's survivability in all-weather combat scenarios. The framework includes 14 systems placed internally and externally on the airframe and offers the primary elements of the suite includes a Radar Warning Receiver (RWR), Missile Approach Warning System (MAWS), flares, and chaff dispenser and Laser Warning Receiver (LWR). All these systems, when working in co-operation, offers situational awareness to the operator against multiple forms of threats, either on the ground or in the air. An additional system, that is provisional, is the X-Guard towed decoy system, produced by Israeli firm Rafael. When installed on a pylon underwing, the system, when retracted, lures incoming radar homing missiles toward itself, protecting the aircraft.

The air-to-ground offensive package is yet another "lucrative" feature. A wide variety of weapons are offered in a Rafale package and each specialises in its job with great efficiency. Starting with AASM Hammer, that is the primary Precision Guided Munition (PGM) and utilises guidance methods like GPS/INS, IIR, or laser (varies as per the variant) to reach targets at ranges upto 50 kilometers. Then there's SCALP EG or "Storm Shadow", a subsonic Air Launched Cruise Missile (ALCM) with terrain hugging capacity to precisely hit fortifications, radar systems, or similar strategic sites at 250 kilometers.

Please note all these systems are embedded in the Indian Air Force's Rafale package and all this is what will make adversaries think of solutions to prevent the tilt of dominance towards India.

JF-17 Block III and J-10C: An attempt to restore the balance?

The news of J-10C procurement by the Pakistan Air Force was indeed all of a sudden, though not a very big surprise as a lot of rumours and speculations were already revolving on various forums about the process of their evaluations. Pakistan was in fact in the first line of potential customers for J-10 back when it was involved in the evaluation of J-10A aircraft, the first serial production variant. However, the several shortcomings in the fighter, both in terms of performance parameters and combat potential didn't offer much scope for its export and it was never seriously pitched in the global market. As the platform matured with enhanced airframe and combat specs, it turned out to be an ideal choice to be called a capable fighter aircraft, in the category

J-10s of the PLAAF

Photo: Vayu

The first batch of 6 J-10s for PAF have arrived (Image via Ali Akbar/SDF)

where American F-16 "Fighting Falcon" and French Mirage 2000 also stands. But now with Pakistan as its first export customer, China is surely looking to attain its rank as one of the leading exporters of military aircraft, something that it had at the time when jets like A/Q-5 'Fantan", F/J-6, F/J-7 or similar were sold in bulk to various Asian and African states.

Produced by one of the leading aerospace giants based in China, Chengdu FC-20CE or J-10CE, is an export-oriented variant. The aircraft is multi-role in nature and offers significant solutions for multiple missions against aerial and ground threats. It is fitted with an AESA radar that offers high scanning ranges that are estimated at around 170-180 km for 5m2 RCS airborne targets. The aircraft will boast PL-15E as its primary BVRAAM solution. With a max operational range of up to 145 kilometers, the missile can neutralise fighter size targets at ranges of 100-120 kilometers. Another factor to speculate is its integrated AESA seeker that offers high Electronic Counter-Counter Measures (ECCM) capability mid-flight.

The aircraft has an InfraRed Search and Track (IRST) as well, which when with its PL-10 IIR missile with High Off BoreSight (HOBS) engagement ability, makes it a dangerous machine in close combat.

JF-17 and its latest Block III iteration come with big enhancements over the previous variants. The old pulse doppler radar is now replaced with NRIET's KLJ-7A(v)2 AESA radar, which, as per the estimates mentioned in the official brochure, can offer 170 kilometers of detection range against 5m2 RCS aircraft. It will utilise the same PL-15E and find itself with great capability to intercept hostiles at medium ranges.

Both the jets are likely to use Chinese KG-600/700 self-protection jammers, which specialise in protecting the aircraft from threats like hostile radars and missiles, operating in X-band and Ku-band frequency respectively.

In the air-to-ground role, the jet utilises all the standard-issue precision guided munitions, including the smart bombs already in service with PAF. However, RAAD Air Launched Cruise Missile (ALCM) is stated to be tested soon with the platform, offering another great solution for standoff strikes. CM-400AKG anti-ship missile is highlight of JF-17's excellent anti-

PAF JF-17s at the Paris Air Show 2019 displaying an array of weapons (Photo: Vayu)

ship capability offering targeting against hostile ships within 180-250 kilometres by utilising a quasi-ballistic flight trajectory, in which when launched, the missile initially gains altitude and then hits the target with a high speed dive.

Overall, both the jets offer similar capabilities in terms of air-to-air combat, and one is not the replacement of the other but in fact, both are going to complement each other in future PAF missions. The acquisition of J-10CE also indicates that PAF wants to reduce its dependency on US-origin F-16AM/BM/C/D/ADF which suffer major operational limitations, like the incapability to link with Airborne Early Warning & Control (AEW&C) aircraft or other systems in service with Pakistan Air Force as they use Link Green (or Link-17) as their standard datalink while F-16 operates with NATO standard Link-16.

Excellent, but not invincible

While there is already enough available document evidence on performance specifications and assumed ratio of success of the particular system, it is still equally important to look at some limitations of the "gamechanger" systems as well. The Meteor missile, for instance, can attain great kill probability at long ranges, it may be ineffective in short-range combat as compared to conventional rocket motor-equipped radar-guided missiles. The intakes placed on the port and starboard side of the fuselage increase the drag in flight and do not provide enough maneuverability in high angles of attack. This is the reason why during sorties, the aircraft also carries MICA's, which is a rocket motor-equipped radar-guided missile and most advisable to be deployed in short to medium range engagements.

PL-15, in another case, though has better fuel capacity, still uses dual pulse rocket motors that are triggered in the boost phase to provide the missile a great speed. It has generally larger No Escape Zone (NEZ) than single pulsed motors, it is still not as big as Meteor's, which has officially the largest NEZ in the league of air-to-air missiles.

Then comes the range factor. Are mentioned figures totally accurate and does the performance remain the same in every situation? The answer is No. The missile also needs desired firing parameters before launch to achieve the desired objective of the kill. When fired on a highly maneuverable target beyond its max effective range, it may not assure the kill due to the fact that it may lose all its speed and inertia in mid-course. Also, when fired from a low altitude to a high altitude, the effect of air drag may cause a great loss of energy that gives a low ability to maneuver and gain the solution to target the foe.

Then we come to radars and that of J-10CE. There is no clear information on the actual specs of the system, along with the name. And that is where the actual strength or weakness of Chinese weapons exists. However, worse problems will be with the JF-17 that is fitted with KLJ-7A. Though carrying 1000+ Transmitter Receiver Modules (TRMs, the number of which is directly performance to the output of radar), it may not achieve the peak performance or even if it does somehow, may not able to continue it for the long term due to the use of an air-cooled system and that too powered by only a single-engine RD-93 turbofan engine, that is generally designed for the low-cost fighter accommodating standard level of avionics suite instead of high-power components. However, even with optimal performance, the aircraft can track multiple airborne hostiles at an estimated range of 130-140 kilometers. Then the RCS factor, most of the radar ranges are advertised by taking 5m2 RCS targets as standard. Rafale's RCS is speculated ≤1m2. So though 170 detection range turns out real for JF-17, tracking Rafale may not be possible beyond 100-110 km, offering Rafale the opportunity of "First Shoot First Kill".

Combat experience matters as well to gain the confidence of the user as well judge the reliability of the machine. Rafale has participated in combat missions over Libya, Afghanistan, Syria, and Iraq. All these conflict-ridden regions had contested airspace as well as threats from ground-based anti-air weaponry. Still, the missions were carried out successfully. J-10CE is yet to see participation in such scenarios. However, Pakistan Air Force had fielded the JF-17 in counter-insurgency missions as well as its renowned Operation Swift Retort.

The Truth of Air Battles

Even though we come across arguments every day on how one jet has superior capabilities over the other jet, either in the same class or different, it is necessary to acknowledge that modern-day air combat is not very likely to happen as 1v1 showdowns. Planning related to any mission that will be carried out by Pakistan Air Force or Indian Air Force will be affected by factors like hostile air defence, target location and weapon availability. Support assets, like an early warning and cover, do play an important role in deciding the winning factor as well.

One Rafale aircraft will never enter Pakistan's airspace to commence a strike or fighter sweep but will be complemented by other assets as well. Like a strike mission where air cover will be provided by Su-30MKI or MiG-29UPG, will be networked with Phalcon or Netra AEW&C, and will involve tactics necessary to evade detection by Pakistan's radar and SAM systems like HQ-9. The same will be the case when J-10C formation comes on a strike; it will receive air support from JF-17 networked with Erieye or ZDK-03 AEW&CS and will make not to get painted by Indian radar and SAM batteries.

Overall, both JF-17 and J-10 reflect the excellence of Chinese aerospace engineering that has come a long way from simple license production to a matured ecosystem involving the successful execution of research and development. They incorporate the technologies that the modern-day fighting force demands and seeks to employ. However, the fact remains that their standalone comparison viz-a-viz highly successful and proven system like Dassault Rafale does not offer them an advantage. However, the quantitative advantage does favour the duo in Pakistan for which the Indian Air Force needs to field a better state of planning in case of full-scale or long-term war that often witnesses confrontations with combat systems fielded in large numbers. Rafale, which is only 36 in number needs to be more strategically utilised than the bulk of JF-17 and J-10CE which will be employed in higher quantities due to their availability in PAF inventory.

Therefore, while Rafale does hold a significant edge over the contemporaries in the west, the actual prediction of aerial battle should not be based on specifications we refer from data sheets but in fact from actual combat, where the aircraft with higher experience controlling the stick and operate with precise situational awareness most likely to come out as the winner!

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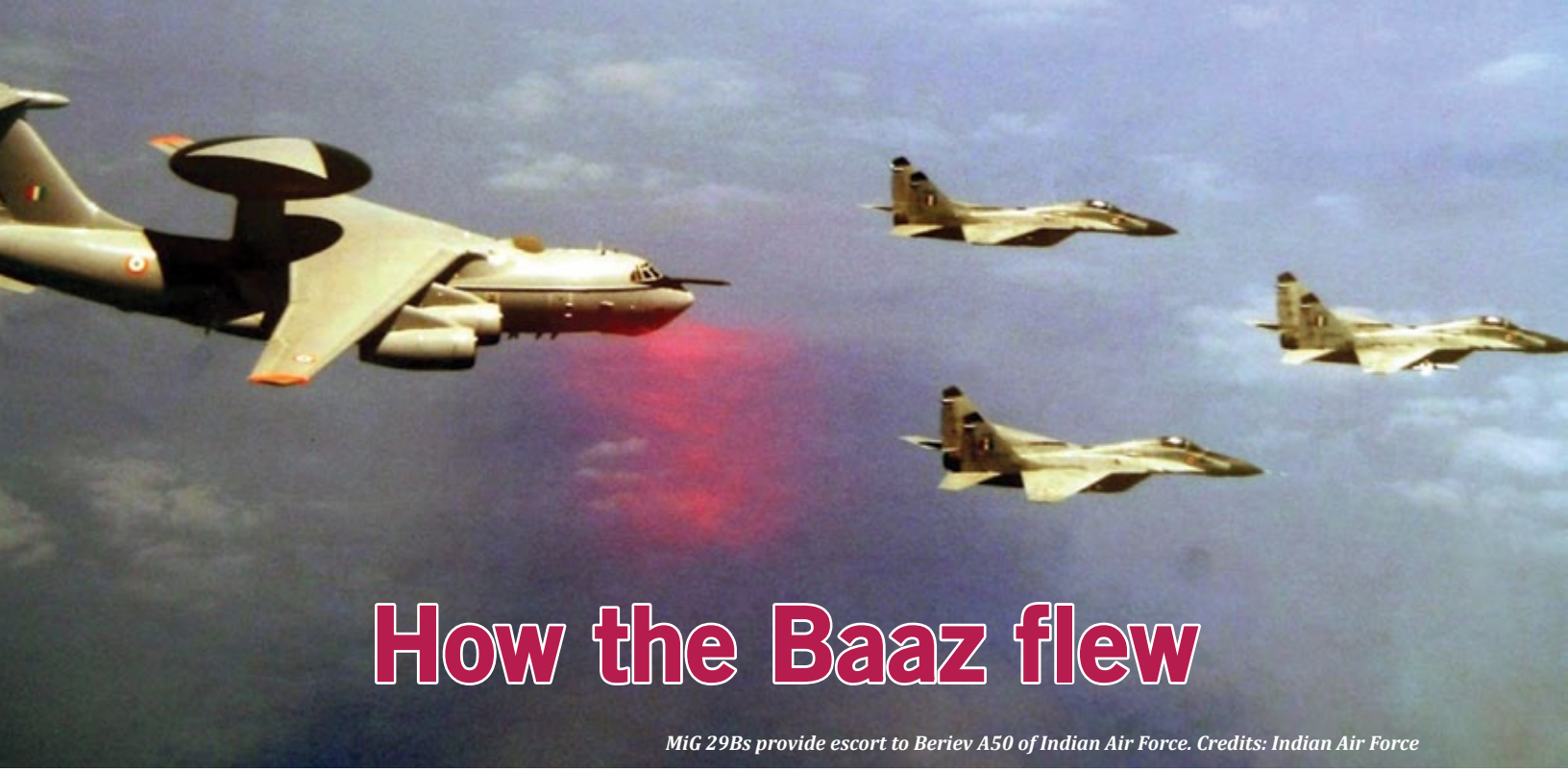

How the Baaz flew

MiG 29Bs provide escort to Beriev A50 of Indian Air Force. Credits: Indian Air Force

Shwetabh Singh traces how the MiG-29 came to be with the IAF

It was in the 1970s-80s that the Indian Air Force was turning a new page and a lot of major acquisition programmes were initiated during the period to replace the older fleet making the air force practically brand new. These were done in the aftermath of one of the most influential aircraft deals by the Indian Air Force, of the MiG-21s. The post-MiG-21 era was significant, because it was that platform, whose acquisition and geopolitical context I have already discussed in my last piece, had seen a new boosted relation of India with the Soviet Union. That deal forged relations that would go on to play an important role for all of India till the USSR collapsed and to Indian Military with a new, albeit weakened, Russia. This era also saw the Indian Air Force being equipped with a diverse set of different platforms, yet the source of these platforms became less diverse, mostly from the USSR.

In this article, I would like to trace how the MiG-29 came to be with the Indian Air Force, though India's contribution to the development cycle of MiG-29 was not as impactful as with the MiG-21, for almost a decade the aircraft was India's Iron Fist against anything our neighbours, both North and West could throw against us, till the original counterpart of MiG-29 in VVS, the Su-30 was also inducted with the Air Force. Hence, it is important to trace the history of the fighter.

The process was although a bit more continual and smoother than what might appear out of this piece because of gaps in my knowledge of events and their motivations, nevertheless I would like to bridge them to the best of my ability. In my opinion, it began singularly with the DPSA programme of the Indian Air Force, which I believe snowballed into the Indian Air Force's composition in the 80s, which created the power dynamics with-respect-to other Air Forces that continued well into the 21st Century, with only the Su-30 acquisition having more impact until now.

The DPSA

The DPSA or Deep Penetration Strike Aircraft programme which began in early 70s and reached its climax in the late 70s, wanted to replace the older air to ground strike aircraft (Hunter/Canberra/ Marut) of the Indian Air Force with a more modern solution. The programme was in consideration since the 1960s when the PAF had acquired its Mirage III platform (Chari). The programme involved participation of Anglo-French SEPECAT Jaguar, British Buccaneer, French Mirage F1, Swedish Saab Viggen. It involved an initial purchase of a

Five Ferry pilots, Flt Lt R Burli, Flt KR Singh, Wg Cdr M McMahon, Flt Lt SCS Adhikari and Flt Lt NM Gupte standing in front of the Direct Supply Jaguars destined for the IAF in 1979. Credits: Bharat Rakshak

small batch and subsequent manufacture of others in the country.

By 1972 all of them had been evaluated by the Indian Air Force. Soviets having recently (1968) sold their Su-7BMKs to the Indian Air Force, pitched its advanced development in form of the swingwing Su-22 Fitter for the DPSA. An IAF evaluation team led by Air Marshal YV Malse, left in 1973, only to find the aircraft unsatisfactory to their needs. The evaluation team's timing also collided with another Soviet product in development. In the early 70s, after a decade of development of MiG-23, under the Shturmovik concept was developing the first ground attack variant, the MiG-23B. The Indian Air Force team was shown around the aircraft but wasn't allowed to evaluate it. The team came back, reporting that Su-22 wasn't what they were looking for and MiG-23B might be worth a second look.

The programme would be shrouded in controversy and the deal would be finally signed by the Janata Party government in 1979, with Jaguar coming out as the winner, for an initial British batch of 40 aircraft and about 120 aircraft being manufactured by HAL. This was the small step that, exaggerated by the geopolitical constraints, would snowball later.

The Mirage Deal

It was reported that a day before the signing of the Jaguar deal, the French approached India with a deal of a lifetime, the Mirage 2000 for the Indian Air Force. The reasoning was related to the SEPECAT, the firm behind Jaguar that IAF had just selected. Jaguar was a joint Anglo-French venture, but the French half of the original consortium, Breguet (whose Alize equipped the Indian Navy) was in financial trouble and French government, worried about the Jaguar programme, asked Dassualt to buy back Breguet. And Marcel Dassault, trying to minimise any and all possible Jaguar liabilities, was trying to pitch his firm's product instead.

This is an important point, for it is generally said that Mirage 2000 was also the answer to PAF's F-16, but it's simply not true. The Mirage 2000 deal was first offered in 1979, in some sense to stop the local manufacture of Jaguar by HAL. The very next year, the winds in Delhi changed with a government change. In January 1980, French President Valery Giscard d'Estaing visited India to strongly pitch for the Mirage

First two batches of Indian pilots training on Mirage 2000 in France.

2000 deal. Mind you, Mirage 2000 wasn't even ready at the point, only 4 prototypes existed at the time, with French AF poised to receive the first of frames in 1983-84 itself. The French tried to sweeten the deal, promising to provide Mirage F1 to plug any capability gap till M2K came, buying back spares of Chetak (Allouette 3, which is a French origin helicopter manufactured by HAL) worth Rs 1.8 crore, and offered the Dauphin helicopter.

The Mirage 2000 (Vajra as it would go on to be called by IAF) would also seem to pass through Indian government and the Indian Air Force higher command like lightning. The Indian Air Force apparently didn't like the haste with which the government was pushing the deal. The Indian Air Force went ahead, assembling an evaluation team under Air Commodore Prithi Singh, to evaluate the fighter in December of 1980 on the fifth prototype. In October 1981, the Cabinet took a hurried decision to purchase the Mirage 2000, and informed the Indian Air Force that a political decision had been taken. The deal was rumored to be of 40 aircraft being bought from Dassault, 45 in CKD kits and rest 65 being made in India, also giving the option of Mirage 4000 if and when the plane develops. By December 1981, the deal for Mirage 2000 had been signed by the Indian government, but of only 110 aircraft unlike the 150 as earlier rumored, with 40 being bought from France and later 70 being manufactured by HAL in India. India would never go on to exercise the local production of M2K, even though France had hoped for it. Their performance during the Kargil War would be so impactful, that the Indian Air Force would again consider ordering a larger amount of the aircraft, but again would only end up ordering 10 more aircraft for a total of 50 frames. The first of the frames would only reach India in 1985, a time anticipated by most, after all Dassault would first serve the French Air Force.

The Floggers enter the picture

On the other side of the world, when DPSA concluded in 1979, with a western machine winning the deal, Soviet Union, which had believed that it had secured the skies of Delhi for its products till now, immediately realised the ground that had slipped by. Realising that the only offer under DPSA, Su-22 was nowhere close to the requirement, something else had to be offered, that had caught the Indian eye, a few years earlier.

The Indian Air Force, with some political pressure, had to invent another programme to keep the Soviets happy. Thus was born the TASA or the Tactical Air Support Aircraft programme. Having tailored the qualitative requirements to fit the Flogger variants on offer by USSR, a major deal was signed to procure ~90 MiG-23BNs to replace the older Su-7BMK and Maruts and a local production of about 165 frames of a variant of MiG-27, the MiG-27ML was signed. Over the course of production, though about ~150 would be produced. The deal was sweetened by the Soviets by including in the mega-package of defence equipment, saving a lot of cost, and by December 1980 itself, the Indian Air Force had started taking the deliveries

MiG 23BNs of No 10 squadron. Source: Unknown

of MiG-23BNs. This would calm the Soviet worries, until the next lightning struck them.

By 1982, it was also clear that PAF was soon bound to get the F-16s, and with Mirage 2000, which IAF had evaluated to be better than F-16s, around 3–4 years away, the Indian Air Force would go on to buy 2 squadrons of MiG-23MFs air defence fighters from USSR, as an immediate capability stop gap should a crisis arise. They would go on to equip No 223 and No 224 squadrons. The Indian Air Force had already evaluated the MiG-23MF, in 1979 when they had evaluated the MiG-23BNs too. But it must be clear that the Mirage deal was well ahead of any indication by PAF to acquire the F-16s, and the timing is merely one that of fortune.

The Mirage deal had other consequences as well. When the Vajra had struck again, it seemed the sheer ground under Soviet Union's feet had slipped (ok maybe I am exaggerating, but they did react strongly). Just as the DPSA fiasco was over, and MiG-23BN had established some semblance of balance, there goes India ordering another advanced Western fighter. They knew MiG-23MF weren't in competition with the Mirage 2000, or maybe even F-16s. They had to bring out the big guns.

The Baaz question

It was in August of 1983, when then Indian Defence Minister R. Venkatraman visited Moscow. The USSR was concerned about India's diversified procurement, and it was made clear to the Indian delegation multiple times. The USSR also tried to pitch possible products, not even yet supplied to the Warsaw Pact countries to retain the Indian military market. It was during that visit that the existence of MiG-29 was first revealed, to Indians and not only Indians but possibly anyone in the world. The existence of the fighter had been hidden and denied to the Indians and the world till that point. People actually knew that such a fighter existed, made as a counter to the F-16s and F-18s, but they didn't know what the plane looked like.

It was in June of 1984 when the first Mirage 2000 meant for the Indian Air Force flew in France, an Indian Air Force training contingent had already been for a few months by then in France, learning to fly the cutting edge machine. It was also the end of that June, by which India was supposed to sign the following local manufacturing agreement. But it had not happened, and it would never happen in the future either. France knew there was a hand in the background that had caused it, the red hand.

The Fulcrum becomes a reality

In the late 1960s, the Kremlin had initiated studies regarding the concept of fourth generation fighters. Three of the major research OKBs, MiG, Sukhoi and Yakovlev were roped in to develop the programme. In 1971, the first qualitative requirements for a fourth generation PFI (Advanced Tactical fighter) were issued. The directives were complicated and at points contradictory. Naturally what would be a solution is development of multiple fighters to fit the list of requirements, but newer technology wasn't cheaper, and it certainly wouldn't help with the general lifecycle costs attached with Russian design philosophy. So, the plan was developed to create two programmes to exhaust as much of the requirements as they can. Thus, were born the PFI/PLMI programmes, to equip the forces. PLMI would later become the LFI programme, Lightweight Tactical Fighter programme.

PFI was supposed to be the heavier variant, to operate deep (250-300 km) beyond enemy airspace, capable of holding on its own. PLMI was supposed to be the lighter fighter, to operate in a tactical battle area of either in friendly territory for air defence or at max 100-150 km beyond its own airspace. The idea was to equip the VVS with 30-35% by strength with PFI and 60-75% with PLMI. This was exactly parallel to the USAF idea of F-16/F-15 coupling that would become the mainstay composition of USAF.

Interestingly, the Indian Air Force would go on to equip both the fighters that come out of PFI and LFI programmes, and that too in completely opposite composition strength as was envisioned by the Soviet planners, with majority of strength being fulfilled by Su-30MKIs and a very small composition of MiG-29s, but that's a completely different context too.

After a lot of configurations and designs were studied by all the bureaus, and in 1972 when VVS issued RFP for a fourth generation aircraft, MiG OKB submitted 2 proposals for a lighter LFI compliant design for the MiG-29, Sukhoi OKB and Yakovlev OKB proposed 2 designs, T10-1 and T10-2 (Sukhoi) and Yak 47 and 45I, for the PFI and LFI respectively. Yakovlev's designs wouldn't make the cut for either programme, with PFI being awarded to Sukhoi's T10-1, which would become the Su-27/30 and LFI to the MiG-29.

Throughout the 70s, more studies and experiments were conducted by both the OKBs on their respective designs with the help of TsAGI and development continued. By 1974, after a competition with Tumanskii (with R67-300) and Izotov (with RD 33) to supply the engine for the MiG-29, Izotov's engine was finally chosen to power the Fulcrum.

By the way, one must mention that since USAF was also developing F-15/F-16s in exactly the same timeline, there was a rush in the Soviet industry to not be losers. MiG OKB was actually working on 2 MiG-29s simultaneously, with same design, engines, flight performance etc but there was a more sophisticated 'pure' MiG-29, with originally envisioned avionics and weapons, while there was also lower cheaper and faster to tarmac, should need be, MiG-29A.

By 1977, the design was finally frozen. Production designations had been assigned to both the versions Product 9.12 and 9.12A (A was the cheaper variant). Interestingly, it was noted through studies that the 9.12A was also very well able to do the job for which 9.12 was being prepared for. By 1982, the MiG-29 had entered full

scale production at (G)AZ — 30 MMZ Znamya Truda in Moscow, although an initial limited series production had already happened by 1979-80.

The Baaz becomes a reality

When the Defence Minister returned, he told the Parliament that India was going to procure "futuristic aircraft to meet the challenge posed by the presence of the F-16 in a neighbouring country". It was in 1984 that the Indian Air Force finally got the chance to evaluate the fighter, becoming the first foreign pilots to fly the type. Two Indian Air Force pilots first evaluated the fighter in 1984, and later teams did in 1985. The team approved of the plane, why wouldn't they? MiG-29 was part of a new generation of Soviet aircraft that didn't look like missiles/tubes with wings, and included a lot of sophisticated design elements, only expected from the western combat aircraft at that time.

In 1984, Soviet Defence Minister Marshal Dmitri Ustinov visited India again, and another firm pitch regarding the MiG-29s was made, including the aspect of local manufacture if India decides to. An immediate deal could not be reached. It was only after the visit of Chief Marshal of Aviation Marshal A I Koldunov and First Deputy Defence Minister Marshae Akhminov that USSR agreed to make deliveries and later a contract was signed.

The French tried to wrestle the deal in their favour, by informing that the Russian planes although cheaper acquired larger maintenance and life cycle costs, thus becoming more expensive than the Mirage 2000. It didn't work. For the next two years, not much would be seen on the deal, and finally in 1986 the deal for the purchase of the first 44 MiG 29B (Product 9.12B) (40 single seaters and 4 twin seaters) was signed in Moscow in the month of May/July. With this India had become the first foreign customer of the Fulcrum, and second only to the Soviet Air Forces.

The initial batch of 8 Indian pilots and 6 ground crew left in 1986 itself to prepare for the plane, undergoing training and conversion at Lugovaya and Frunze in Kazakhstan during October 1986. Mind you, Soviets were initially going to supply the plane in April-May 1987, but later they expedited the deliveries to December of 1986 itself. The first two MiG-29 squadrons, No 28 and No 47 were commissioned in mid-1987 with the Indian Air Force. Indian MiG-29s were to come equipped with R27 BVRAAM, R60 SRAAM, and later R73 SRAAM, and with the N019 Sapfir 29 lookdown-shootdown pulse doppler radar.

Soviets had imagined MiG-29 would be quite successful with the IAF, maybe to the orders of MiG-21, maybe to the likes of MiG-27 even, and had offered local production. In February of 1987, a high-level delegation led by Minister of Aviation Industry Apollon Systsov arrived on a 10 day visit to India, and talks were held on local manufacturing of the plane, but it didn't materialise into anything. The early planning around the plane involved discussion for buying 6-8 squadrons of the plane and hence the local production made sense, but the first commissioning was followed by a few world changing events, along the lines of collapse of USSR itself, India going almost bankrupt and liberalising the economy in 1991. Any further plans for MiG-29s were dropped. In 1989, USSR informed India that they were developing a newer variant of MiG-29 with higher fuel capacity and with Fly-By-Wire system, to hedge against a possible order for more Mirage 2000, after all M2K was offering FBW in 1982 that too with local production.

All aircraft inducted since the DPSA are in this 60th Anniversary pic of IAF. Credit: Indian Air Force

MiG 29UPG of Indian Air Force. Credit: Indian Air Force

IAF MiG-29UPG (Photo: Simon Watson)

So, let's just recap here, it was the result of DPSA that the French offered Indians the Mirage 2000, it was the DPSA that also prompted Soviets to pitch MiG-23BN and MiG-27ML to India. It was the signing of Mirage 2000 that alerted the Soviets to finally pitch the MiG-29 to India, well before anyone in the world.

In 1994, there was chatter of PAF acquiring more F-16s, and subsequently India started having talks with the new Russia to procure more MiG-29s. The talks involved acquiring the newer MiG-29M (Product 9.15)s, which were built for erstwhile USSR but were unpaid for. Yet when the order came, MiG-MAPO sold India the older 9.12Bs from their stockpile. Maybe if they had sold MiG-29M, a better variant, they would have seen further orders, instead it helped to divert Indian attention to the Sukhoi and their Su-27/30 on offer. Although the talks included some 36 frames, India would later order only 10 more MiG-29s.

All in all, India would only ever induct three squadrons of MiG-29s, with a little non-uniform composition. The first two units being No 47 and No 28, and later No 223, which was actually one of the two MiG-23MF squadrons, would convert to MiG-29s.

I think I must make a few points clear too, MiG-29 when it came out in 1980s wasn't a multi-role aircraft, more of an air-defence/air-superiority fighter meant for A2A roles, which the design OKB realised was a mistake from their end, while Mirage 2000 since the beginning was meant to be a true multi-role aircraft, and was quite many leaps ahead in terms of technology compared to the Fulcrum. This point was important, especially when the talks about local production were undertaken for both aircraft. Manufacturing Jaguar itself was a technological jump for HAL, and when talks with the French about not exercising the local manufacturing clause of Jaguar but rather for Mirage 2000 were undergoing, it was a point of serious consideration that whether HAL would be able to make such a sophisticated aircraft at all, even with French TOT. Soviets on the other hand, were also playing into this. When they pitched MiG-29s' local manufacturing, a point was made that MiG-29s were easier to manufacture than Mirage 2000, and the Fulcrum had some commonality with the MiG-27ML already under production by HAL and thus it would make sense. Alas, as fate would have it, India would not go on manufacture either of those planes, and both of them would perform to the satisfaction of the Indian Air Force in the next conflict of Kargil.

On 7 March 2008 after approximately two decades in service, the Indian Air Force decided to give a new life to these old birds with the signing of the UPG upgrade programme. This aimed to bring Indian MiG-29s upto the Russian MiG-29SMT standard, called the MiG-29UPG (Product 9.20). This included a new fire control suite, with a new Zhuk ME slotted array radar, new IRST and at India's request few other foreign and Indian avionics equipment were also integrated. The programme also saw a few structural changes, with addition of an A2A refueling probe, an enlarged fuel tank. The first six MiG-29s from India flew to Russia after the deal in 2008 itself, and the first flight of the first upgraded MiG 29 happened from Zhukhovskii in 2010. After an initial upgraded batch from Russia, the rest of the fleet was upgraded in India itself at 11 Base Repair Depot.

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References

- Bobb, Dilip. "India's defence needs dragged to sacrificial altar of politics". *India Today*. August 15, 1980.
- Bobb, Dilip."India's defence buys start to resemble a Rubik's Cube of puzzling and complex moves". *India Today*. November 15, 1981.
- Bobb, Dilip. "India unsuccessfully tries to keep Mirage 2000 deal with France under wraps". *India Today*. February 28, 1982.
- Bobb, Dilip. "French-built Mirage-2000 warplane ready to be formally handed over to IAF". *India Today*. June 30, 1984.
- Chari, P. R. 1978. *The DPSA Decision*, Strategic Analysis, 2:7, 233-236
- Gordon, Yefim. *Mikoyan MiG-29*. Midland, 2007.
- Rajkumar, Philip. "Evaluating Fighter aircraft in the Soviet Union".
- Singh, Raminder. "Air defence aircraft MiG 29 to give IAF complete mastery over South Asian skies". *India Today*. August 15, 1986.
- Singh, Roopa. "Jaguar to give India formidable aerial striking capacity". *India Today*. October 31, 1978.
- "MiG 29UPG Upgrade programme goes on". *Take Off*. 2012.

A look at select air-to-air missiles

An analysis of the main types and differences between Chinese, Russian and Western missiles

US Navy and Marine aviators have been using the Raytheon AIM-7 Sparrow and the AIM-120 advanced medium-range air-to-air missiles (AMRAAMs—as shown on the F/A-18C Hornet above) since their development in the 1980s. (Photo: US Navy)

This article examines the main types of air-to-air missiles (AAMs) which govern air combat. Modern air combat is extremely dynamic, and the presence/absence of capable AAMs and the skills behind their employment can make a significant difference in deciding the outcome of an air battle.

The main factors of AAMs that need to be considered are: weapon carriage capacity and the probability of kill (P_k). The P_k depends on several factors: the separation between the launch aircraft and the target aircraft; the speed, altitude and bearing/aspect of the launch aircraft relative to the target aircraft; the counter measures employed by the target aircraft; the agility of the target aircraft and the capability of the AAM itself. The no-escape zone (NEZ) of an AAM is defined as the zone in which the missile has enough energy to intercept the target aircraft, irrespective of any evasive manoeuvres performed by the target aircraft.

Specifically, there are three main types of air-to-air missiles. The first ones are "heat seeking" missiles, equipped with an infrared (IR) seeker that homes in on the heat generated by the engines of the aircraft and the friction between the skin of the aircraft and the surrounding air. Modern IR missiles are extremely agile and can even sustain turns of 50 g or more, have high off-boresight (HOBS) capability and can also be cued using helmet-mounted sights (HMS). HMS allows pilots to designate and lock the target aircraft by simply looking at them. The HOBS capability can be as high as 90 degrees, although missiles such as Israel's Python 5 and European IRIS-T also authorise a full 360 degrees launch envelope. Modern iterations also feature an imaging infrared (IIR/I2R) seeker which are programmed to recognise the expected shape of target aircraft, thus making them more resistant to countermeasures. Some IR missiles also feature multi-band ultraviolet (UV) seekers which allows for better discrimination between target aircraft and flares. Some of them are capable of lock-on-after-launch (LOAL) engagements and can be used for targets directly behind the launch aircraft (known as over-the-shoulder firing). Generally, these missiles are used for within visual range (WVR) engagements (or dogfighting), although France and Russia have also developed beyond visual range (BVR) IR homing missiles in the form of MBDA's MICA and R-27T/ET. Most prominent missiles in this category include the Russian R-73, American AIM-9 Sidewinder and MBDA's AIM-132 ASRAAM. Due to their passive nature, these missiles do not provide any indication on radar warning receiver (RWR) of the target aircraft, and their launch can only be detected either visually or with the help of missile approach warning system (MAWS). As such, WVR combat remains exceptionally dangerous.

The second category of air-to-air missiles are semi-active radar-guided missiles. These missiles require the target aircraft to be illuminated and locked in single-target-track (STT) or track-while-scan (TWS) mode by the launch aircraft's radar and then the missile homes in on the radar energy reflected from the target aircraft. STT is a technique where the launch aircraft's radar focuses all of its energy on the target in a narrow cone, thus providing the highest fidelity (resolution) tracking solution. However, this does not allow simultaneous tracking of other targets and if the target aircraft is equipped with a radar warning receiver (RWR), it will receive an indication that it is being locked. In TWS, the launch aircraft's radar tracks multiple targets simultaneous, and consequently, allows for multiple simultaneous engagements. However, since multiple targets are tracked

simultaneously, the track fidelity is lower and the RWR of the target aircraft may or may not give an indication that it is being locked. These missiles are cost-effective, as the use of a passive seeker in the missile is much easier and cheaper. The prominent examples of these types of missiles include the American AIM-7 Sparrow, Russian R-27R/ER and French Matra Super 530D.

The third and most important category of air-to-air missiles is the active radar-guided missiles. These missiles feature an onboard active radar seeker which guides the missile during the terminal phases of the missile's flight profile. However, the missile's active radar seeker is quite small when compared to the launch aircraft's radar. Hence, the tracking range of the missile's seeker is quite small and as such, the missile is guided by the radar of the launch aircraft before the missile goes "pitbull" (the informative call when missile's seeker becomes active). Active radar homing air-to-air missiles can also be launched in fully autonomous (fire and forget) mode without any targeting information and mid-course guidance from the launch aircraft's radar, but this poses the risk of destroying friendly aircraft and other unintended targets, and a much lower P_k. These missiles can also be fired using targeting information and guidance from off-board sensors, via a datalink. The most prominent examples of these types of missiles include the American AIM-120 AMRAAM, Russian R-77, MBDA's Meteor, Chinese PL-12 & PL-15 and Indian Astra.

China

The Chinese have made remarkable progress in the domain of AAMs since the mid-2000s and this rapid pace of development has placed China among handful of nations with defence industrial base capable of producing such advanced AAMs. The People's Liberation Army Air Force (PLAAF) and People's Liberation Army Naval Air Force (PLANAF) has introduced two indigenous active radar-guided missiles, the PL-12 and the PL-15, and an indigenous short-range imaging-infrared missile, the PL-10.

In 2015-16, the PL-10 entered into service. The PL-10 features an imaging-infrared (IIR) seeker, thrust vector control and can perform all-aspect shots at very high G-loadings. The PL-10 can be cued using a helmet-mounted sight (HMS) and has off-bore sight launch capability of 90 degrees, which makes it particularly lethal during dogfights. The PL-10 also features a laser proximity fuse and has lock-on-after-launch (LOAL) capability which enables engagements beyond the seeker acquisition range. It is also very possible that PL-10 possesses over-the-shoulder firing capability in lock-on-after-launch (LOAL) mode. The estimated effective range is between 30-40 km. In terms of performance, the PL-10 is comparable to the MBDA's AIM-132 ASRAAM and has a superior kinematic performance when compared to the American AIM-9X Sidewinder.

The PL-12 was China's first indigenous active radar-guided missile and entered operational service in 2005. The PL-12

Models of FC-31 and a PL-15E missile on display at Airshow China 2021 in Zhuhai (Photo: Global Times)

A Chinese J-20 armed with PL-15 missiles (Photo: Wikipedia)

was developed to counter the American AIM-120 AMRAAM and the seeker was developed with Russian help on the basis of imported Russian R-77 seeker heads. In terms of performance, the PL-12 is comparable to the Russian R-77 or the American AIM-120C-4. The estimated maximum range is between 60-90 km, which is between that of AIM-120B and AIM-120C-5. The PL-12 has a dual-pulse rocket motor and a radio proximity fuse, which gives it a very decent NEZ. Newer versions of the PL-12 have also been developed with several modifications. These modifications include an anti-radiation seeker, better ECCM (electronic counter countermeasures) capabilities and improved datalinks for mid-course guidance. The PL-12C featured folding fins to allow for carriage in the internal weapons bay of

A model of an export version of the PL-12, SD-10A, (bottom-left corner) with JF-17 on display at the Farnborough Airshow.

Chengdu J-20. Ramjet propulsion, on the lines of MBDA's Meteor active radar-guided beyond visual range air-to-air missile (BVRAAM), was also tested on PL-12D. However, no evidence exists that these variants entered operational service, instead they were used to develop PL-12's successor, the PL-15. The PL-12 was also exported under the designation SD-10A/B for use on the JF-17 Thunder's of the Pakistan Air Force (PAF). The SD-10B has a much larger NEZ and better P_k and ECCM capability than SD-10A. The SD-10B is also reported to have an anti-radiation seeker for engagement of airborne early-warning (AEW) aircraft.

The PL-12's successor, the PL-15 also has a dual-pulse rocket motor and an AESA seeker, which provides it with a very potent ECCM capability. The AESA seeker allows for much faster detection and classification of aerial targets including LO and VLO designs, better detection ranges, enhanced resistance to countermeasures, LPI/LPD capabilities and improved reliability. China is one of the few nations to have used an AESA seeker on an AAM, with the only other confirmed use being on the Japanese AAM-4B AAM. The PL-15 also has cropped fins for carriage in the internal weapons bay of Chengdu J-20 and other future stealth combat jets of China. The PL-15's maximum range is estimated to be around 200 km. As such, the PL-15 outranges the latest American AIM-120D AMRAAM. The maximum range of PL-15 is comparable to the MBDA's Meteor BVRAAM, although Meteor retains significantly larger NEZ and a much higher P_k due to its ramjet propulsion. It is also believed that the PL-15 features passive guidance and can receive targeting information and mid-course guidance from airborne early warning and control (AEW&C) platforms currently in service with the PLAAF. The PL-15 is expected to replace PL-12 as the standard BVR armament for PLAAF and PLANAF fleets in the future. The export variant of the PL-15, designated as PL-15E, has a maximum range of 145 km. The PL-15E is also scheduled to be integrated on to the JF-17 Thunder Block III's of the Pakistan Air Force (PAF). PAF's recently inducted Chengdu J-10CE are also confirmed to have been integrated with PL-15E.

A very long-range AAM, known as PL-X or PL-17 is also under development in China. The maximum range is estimated to be around 400 km with a very high-altitude cruise phase. A lofted trajectory will also be used to minimise drag, in altitudes in excess of 30,000 meters. The missile is expected to feature a dual-mode guidance, with an active radar seeker and an IR-homing seeker. The dual-mode guidance will make the missile more resistant to countermeasures as well as improve target selection capability. The missile is 6 meters long and only has four cropped fins at the tail and no control surfaces at the mid body, suggesting that the design is optimised for stable flight trajectory and maximising range, and not high manoeuvrability. Given the large cross-section of the missile body, the radome could accommodate a large seeker that could have a detection range of 40-50 km or more against large radar cross-section (RCS) platforms such as refuelling tankers, airborne early-warning aircraft, ISTAR aircraft and other high value assets. In such very long-range engagement scenarios, the missile would also most likely receive targeting information and mid-course guidance from networked and third-party sensors. So far, only the Shenyang J-16 seems to be the launch platform of the missile due to its large dimensions.

Russia

After the collapse of the Soviet Union, the development of air-to-air missiles suffered badly in Russia due to the dire state of the Russian economy and substantial cuts in defence R&D spending. Multiple projects were subsequently cancelled. However, Russia has now begun to bounce back and recapitalise on the development of air-to-air weapons.

The primary short-range AAM in service with the Russian Aerospace Forces (VKS) is the infrared-homing R-73 (AA-11 Archer), that entered service in 1984 and was widely regarded as a gamechanger due to its high off-bore sight (HOBS) capability of 40 degrees. The VKS has started receiving deliveries of an improved variant of R-73, designated as R-74M. Although the R-74M has better kinematic performance, range and HOBS capability (60 degrees) than R-73 and an improved seeker for target acquisition, the lack of a modern imaging IR/UV seeker makes it vulnerable to countermeasures such as flares and DIRCMs (directional infrared

RuAF Su-27 equipped with Kh-31, R-27, R-73 and R-77 missiles (Photo: NPO Saturn)

Russian Air Force Su-30SM along with R-27RE and R-73 missiles (Photo: Russian MoD)

countermeasures). Russia has now switched its focus to the K-74M2, or Izdeliye 760 (the K prefix denotes a missile that is still in the development phase), which is optimised for carriage in the internal weapons bay of the Sukhoi Su-57. The K-74M2 is expected to feature an IIR seeker, and a rocket motor for increased burn time, for longer range. The K-74M2 can also be fired in lock-on-after-launch (LOAL) mode, which is typically required when launched from an internal weapons bay, as the missile begins its flight under inertial control before achieving an in-flight lock on the target.

For BVR engagements, the medium-range R-27 (AA-10 Alamo) was developed during the 1980s. The extended range variants of R-27, designated as R-27ET (IR-guided) and R-27ER (semi-active radar-guided) were also developed. The range is comparable to AIM-120B AMRAAM, but the energy loss at higher ranges is slightly higher due to the presence of larger control surfaces. Active radar homing versions of R-27, designated as R-27EA/EM, were also developed, but never entered operational service with the VKS.

The R-77, or Izdeliye (AA-12A Adder) medium-range active radar homing missile was also developed by Russia during the 1990s, but was never procured for the VKS. As such, it remained predominantly an export product, with India and China being the main export customers. An improved variant of the R-77, called R-77-1, or Izdeliye 170-1 (AA-12B Adder) was finally introduced in service in 2015, with an upgraded seeker, improved resistance to countermeasures, aerodynamic refinements, longer range and improved shelf and carriage life. The R-77 and R-77-1 feature a unique lattice fin arrangement at the rear, which helps in maximising manoeuvrability, but also induces higher aerodynamic drag at longer ranges. The maximum range of R-77-1 is little more than 100 km, but has inferior performance when compared to the C-variants of AIM-120 AMRAAM at longer ranges. The R-77-1 was first operationally deployed in 2015 with the Sukhoi Su-35S in Syria.

The K-77M, or Izdeliye 180, is the next stage in the development of the R-77. The K-77M features conventional fins instead of the lattice fin arrangement. This allows for internal carriage by Sukhoi Su-57 and also reduces aerodynamic drag and radar cross-section. Other changes include a new dual-

Russian Air Force Su-30SM along with R-27RE missiles (Photo: Russian MoD)

pulse rocket motor and a further upgraded seeker. The dual-pulse rocket motor ensures an extended range, more thrust output during the missile's flight profile and higher energy for terminal manoeuvres. Vympel, the missile's manufacturer, has claimed that the K-77M will be superior to AIM-120C-7 AMRAAM, and comparable to subsequent AMRAAM developments – presumably, the AIM-120D AMRAAM. Vympel also claims that the K-77M is capable of engaging anti-aircraft missiles fired at the launch aircraft, even missiles approaching from rear. As per unconfirmed reports, K-77M will have a range double of that of R-77. This would suggest a range of more than 160 km.

A ramjet-powered variant of K-77M, designated as K-77ME, or Izdeliye 180-PD (the suffix PD stands for Priamotochnyi Dvigatel, or ramjet engine in Russian) is also speculated to be under development. This speculation stems from a video released by the Russian Ministry of Defence in which a Sukhoi Su-57 was seen carrying an air-to-air missile with an air intake (very possibly for the ramjet engine) on an external pylon.

When it comes to very long-range engagement scenarios, Russia has developed the hypersonic R-37M, or Izdeliye 610M (AA-13 Axehead) active radar-guided air-to-air missile. The R-37M is much larger, heavier and more expensive missile than specimens of the R-77 and R-27 family. The missile is estimated to have a range of more than 200 km, with the primary launch platforms being the Mikoyan MiG-31BM and Sukhoi Su-35S. As such, the weapon is expected to outrange MBDA's Meteor and AIM-120D AMRAAM. The missile is intended for use against high value assets such as airborne early warning and control (AEW&C) aircraft, refuelling tankers, etc. The R-37M is the primary armament of Mikoyan MiG-31BM interceptor, and according to Russian media reports, it can be used to shoot down ballistic missiles and low-flying cruise missiles. The Sukhoi Su-35S can carry a maximum of four R-37Ms; one under each wing and two underneath the fuselage. According to the missile's manufacturer, the missile can engage "some types" of aerial targets at ranges of up to 124 miles. This suggests that only larger and probably less agile targets can be engaged at the limits of missile's flight envelope. The missile is powered by a dual-pulse solid rocket motor. Also, as per the manufacturer, during the terminal phase of engagement, the seeker can lock on to a target with 54 square foot radar cross-section at ranges of 25 miles or more.

The West

Currently, the most potent air-to-air missile for beyond visual-range engagements of fighter-size targets in service anywhere in the world, is MBDA's Meteor. The Meteor's most impressive feature is its propulsion system. The Meteor uses a solid fuel, ducted ramjet engine, instead of the traditional rocket motor found on most air-to-air missiles. With its ramjet engine, the Meteor can throttle itself during different phases of the missile's flight profile, whereas a traditional rocket engine delivers all of its energy in a continuous burn. A typical BVRAAM usually has a burn phase, in which due to the combustion of the propellant, the missile gains energy while usually climbing to a high altitude. This burn phase lasts only for a few seconds. The missile then glides on its built-up energy to its predicted impact point of the target aircraft and dives on to the target in the terminal attack phase with gravity on its side to maximise its ability to make hard manoeuvres. In case of the ramjet-powered Meteor, the engine can throttle itself during the cruise phase, and then in the terminal attack phase, the engine can throttle up again to maximise energy (around Mach 4.5) and make hard manoeuvres. This significantly increases the missile's no-escape zone (NEZ). As such, the missile's manufacturer, MBDA claims Meteor has the longest NEZ among all the BVRAAMs in the world.

The Meteor features an active X-band radar seeker and an impact and RF proximity fuse. The missile also has a two-way datalink and network centric capability. With its network centric capability, the Meteor can receive targeting information and telemetry updates from third-party sensors, including other fighters, airborne early warning and control (AEW&C) aircraft, land-based radars, etc. The two-way datalink capability allows the pilot to re-target the missile after it has been launched. The missile also transmits back its state parameters such as fuel and position back to the launch aircraft in real-time. The two-way datalink also ensures a hit/kill assessment, better ECM resistance and better guidance since the launch aircraft's mission computers can know the exact position of the missile instead of calculating where it probably is. The two-day datalink is fully operational on the Eurofighter Typhoon and Saab Gripen.

The most popular beyond visual-range air-to-air missile (BVRAAM) is the American AIM-120 AMRAAM, built by the US-based Raytheon. Its latest iteration, the AIM-120D AMRAAM, is powered by a dual-pulse solid rocket motor, features a highly jam-resistant RF seeker, and a two-way datalink. The AIM-120D AMRAAM also has third-party targeting capabilities like the Meteor and boasts an additional 50% range over its previous version, the AIM-120C-7 AMRAAM. The maximum range for the D-model is estimated to be around 160-170 km. The AIM-120D AMRAAM is also speculated to have an AESA seeker, though it is not confirmed.

MBDA Meteor on German Air Force Eurofighter Typhoon (Photo: MBDA)

An F-35 fires an AMRAAM (Photo: Raytheon)

An AMRAAM F3R missile is launched from an F/A-18F during a test (Photo: Raytheon)

Despite its proven record, the AIM-120 AMRAAM is finally showing its age, and is slowly being outperformed by its Chinese rivals. As such, the US has awarded Lockheed Martin to develop AMRAAM's successor, the highly secretive AIM-260 JATM (Joint Air Tactical Missile). The United States Air Force (USAF) has publicly stated that the development of the Chinese PL-15 is one of the primary reasons behind the initiation of the AIM-260 JATM programme. The AIM-260 JATM is expected to have the same dimensions, the length and the diameter as the AIM-120 AMRAAM, probably to accommodate the weapon in the internal weapon bays of the stealth fighters, the F-22 and F-35 of the US. These dimensional requirements rule out the possibility of ramjet propulsion, and hints at the possibility of a dual-pulse rocket motor with better higher energy density propellant. Given the extreme secrecy the JATM programme is wrapped around, the missile may also very likely feature an AESA seeker, two-way datalink and third-party targeting capabilities. The possibility of dual-mode seeker, radar and imaging infrared (IIR) also cannot be ignored. Majority of the details about the AIM-260 JATM remains classified, but it confirmed that the Pentagon aims the missile to achieve initial operating capability (IOC) in 2022.

Apart from the AIM-260 JATM, the US-based Raytheon is also developing a long-range air-to-air missile, known as the Long-Range Engagement Weapon (LREW). Again, the LREW programme is extremely classified. This munition is expected to be a two-stage missile. This speculation emerges from the fact that the official concept art of the programme depicts a two-stage missile being launched from the internal weapons bay of an F-22.

Raytheon is presently also developing a new medium-range missile, known as Peregrine for use against drones, manned aircraft and cruise missiles. Raytheon plans to offer Peregrine missile as a complement to the AIM-120 AMRAAM and the AIM-9X Sidewinder, both of which are manufactured by Raytheon. Raytheon has stated that Peregrine will have the range of an AMRAAM and the manoeuvrability of a Sidewinder, and a length of six feet and weight of 150 pounds. But, since different variants of AMRAAM have different ranges, it is unclear which one Raytheon has referenced for comparison. To put things into perspective, the AMRAAM has a length of 12 feet and a weight of 345 pounds. This could effectively double the number of air-to-air munitions carried internally by the F-22 and F-35 in their stealthy configurations. Raytheon has also stated that the missile will feature a multi-mode seeker, including an imaging-infrared and a blast fragmentation warhead. The most likely option would be the combination of the radar seeker of AIM-120 AMRAAM and imaging-infrared seeker of AIM-9X Sidewinder. The multi-mode seeker will make the missile highly resistant to electronic jamming, as the missile can switch to infrared guidance. In case countermeasures are employed to blind the missile's infrared seeker, the missile can revert back to radar guidance. The missile's physical models presented by Raytheon almost certainly confirm an advanced rocket motor for propulsion. This is likely to contain a high energy density propellant and multi-pulse rocket motor. Currently, the Peregrine is an internally-funded project of Raytheon.

Article by Pushpan
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Raytheon's Peregrine. (Image: Raytheon)

Making Drones Intelligent

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Introduction

There is increasing awareness about drones owing to media, movies, gaming industry, and the increasing proliferation of drones into everyday lives. Reducing costs and sizes, and increasing capability of electronic hardware, advances in wireless communication, signal processing and artificial intelligence techniques, and embedding of all of these into drones are not just facilitating exciting missions with smaller aircrafts, but are enabling an entirely new class of applications that were not even thought of before.

Most present-day drones primarily collect data, largely photos and videos. Most of them are either being remotely piloted, or the flight path is pre-programmed into them. In terms of dynamic action, some operations are operator-in-the-loop, for example circumventing obstacles using first-pilot-view or dropping relief material by pressing a button upon seeing people in video. A large part of intelligence is drawn by teams sitting in operation rooms by manual analysis and post-processing of data, for example detecting movement patterns of individuals.

Increasing drone operations are resulting in an ever-increasing volume of data, which is getting beyond human capacity to process. Getting full-motion video from long-range flights consumes a lot of bandwidth, and also introduces delays that may be unacceptable for fast maneuvers. Furthermore, many operations like disaster relief are time sensitive. In the case of defence, the time from sense-to-act may be crucial for not only conflict resolution but even survival. High-resolution sensors, sensing in multiple spectra, intelligent processing, and autonomous operations are not only desirable, they are becoming essential. Increasingly many applications call for swarm/group operations, requiring dynamic message exchanges and smart onboard processing.

Drones come in various size and weight classes, each having a specific role to play in any given mission. While some of the text in this article is generic enough to be applied to many categories, the focus of this article is the nano-micro-mini category of air vehicles only.

It takes many different technologies to make a drone mission successful, e.g., aerodynamics, structures, flight control systems, datalinks, ground control station, ground checkout systems, powerplant, mission sensors and computer, signal processing algorithms, data fusion algorithms, artificial intelligence algorithms, and so on. This article is restricted to the subsystems that are responsible for providing 'intelligence' to the drone, i.e., the mission system, signal processing, data fusion, cooperative control, and artificial intelligence.

Ingredients of Intelligent Operations

All living beings derive intelligence from sensing their environment using sensors provided to them by Nature, and processing the sensed information in their brain.

Humans have 5 primary senses, viz., sight, hearing, touch, smell, and taste. In addition, humans have a sense of time, and sense of space around them; these two can be termed as situational awareness sensors.

Human brain is the biggest and most advanced of all the species. Animals and insects may not have as much of sensing and processing capacity; however, many of them possess unique capabilities. For example, birds see ultraviolet light. Bees measure distances by sensing optical flow. Dogs can hear much higher frequency ranges and have 50 times more olfactory receptors compared to humans and have a great part of the brain for analysis of smell. Cats can hear a wide range of frequencies of sounds. Ants have the unique capability of leaving pheromone trails upon returning from a food source, for other ants to follow. Bees are excellent group workers.

The capabilities of sensors and processors today have not even reached the levels of those of animals and insects. Research in the field of sensing and sensor data processing can be divided into four streams as follows: i) to increase the sensitivity, range, and resolution of the existing types of sensors, ii) study of insects' senses and behaviours and applying that knowledge to create newer types of sensors and/or algorithms, iii) advances in signal processing and data fusion techniques to infer intelligence information from the sensed data, and iv) advances in artificial intelligence technology.

Sensors

Let us look at some mission sensors drones may carry. For most of these sensors, key benchmark parameters are range, accuracy, precision, and resolution. While it is intuitive to think of high-resolution sensors for better surveillance, one must weigh the tradeoff related to higher processing power and/or bandwidth requirement for the increased data frame size, if the coverage must remain constant.

Sight/ Vision

Sight is considered to be one of the most important sensors both for living beings and drones. For drones, sight or vision is enabled through cameras, which essentially comprise of an imaging chip, a lens, and some supporting electronics and software (Figure 1).

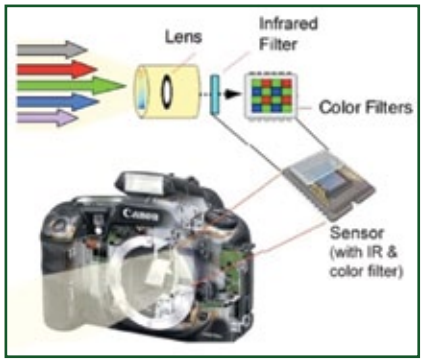


Figure 1: Typical Digital Camera (Image courtesy https://www.studiopsis.com/how-a-digital-camera-works/)

Images and videos from cameras can be used for two different purposes. First, surveillance tasks such as object detection/ recognition/ classification, finding geolocation of objects, static and moving object tracking, human detection, face detection/ recognition, perimeter/ border crossing, violent activity detection. (Figure 2).

Figure 2: Drone-based Surveillance (Image courtesy https://wordlesstech.com/real-time-drone-surveillance-system-for-suspicious-activity/*)*

Second, aid in navigation such as see-and-avoid, object following, vision-based landing, horizon-based estimation of roll and pitch (Figure 3).

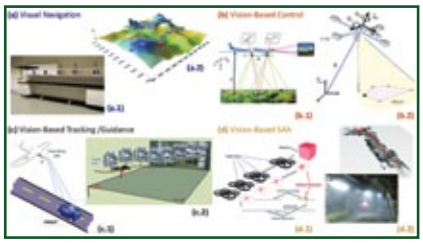


Figure 3: Vision-based Navigation of Drones

Hearing/ Auditory

Hearing can be considered as the second most important sensor after vision. Voice commands can ease human-machine interaction. For surveillance missions, things like voice recognition, language identification and understanding are valuable. For wildlife monitoring, classification of sounds of birds and animals is helpful. Gun-shot detection and direction finding (Figure 4) is an important application.

Figure 4: Acoustic Localisation Sensor *(Image courtesy Microflown AVISA)*

Smell/Olfactory

Smell can give indication of leakage of toxic gases and indicate presence of other harmful chemicals or pathogens. Early detection of these can help save disasters and even save lives. A lot of research is being carried out in the areas of 'Electronic Nose', based on bio and/or chemical sensors (See Figure 5).

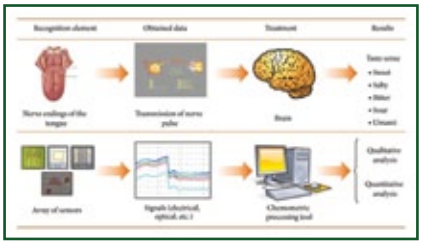


Figure 5: Electronic Nose

Taste/ Gustatory

Taste can detect the presence of specific chemicals in a substance. Chemical and biosensors can be used for making a gustatory sensor (See Figure 6)

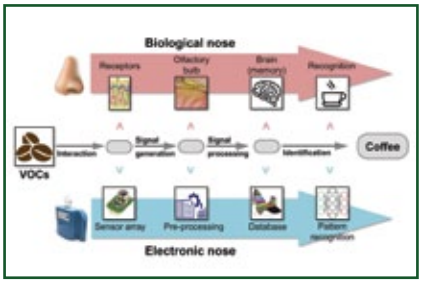


Figure 6: Electronic Tongue

Touch/ Force/ Tactile

Tactile sensors can be used for sensing proximity, contact, and pressure sensing among others (Figure 7). Drones can use them for weapon delivery upon reaching a target, or responding to an action from another drone in a team operation. Drones are also being used for delivery of items. Since increase in all-up weight can reduce endurance, there is motivation to reduce weight of the packaging and holding material. For delicate items, tactile sensors can be used for sensing the right amount of pressure to be exerted.

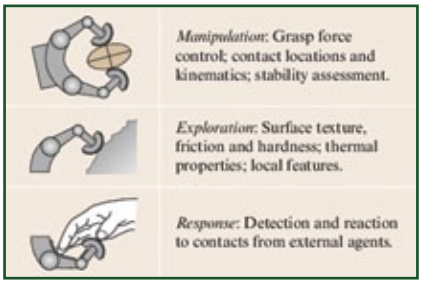


Figure 7: Tactile Sensors

Space/ Situational Awareness

The most important situational awareness element for drones is its location in the 3D world. Traditional navigation with GPS and inertial sensors serves most purposes; however, GPS may not be available indoors and under forest cover. Also, accuracy of GPS location may not be sufficient for precision maneuvers. Flying at low altitudes, small drones may find many static and dynamic obstacles in the path. It's not practical to set very fine-grained routes, and as such it cannot work for dynamic obstacles. Advanced techniques such as vision-based navigation, landing, and object following, Lidar or sonar based obstacle detection, etc. are proposed.

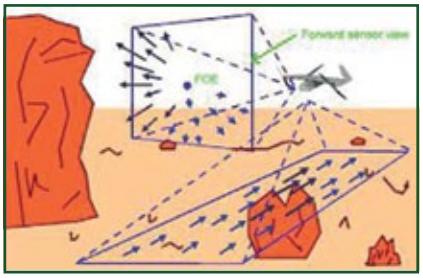


Figure 8: Optical Flow

Time: Accurate inference and precise navigation requires that the data used for signal processing and fusion at a given time instance be all registered and correlated with good accuracy. Different sensors output data with different frequencies, and also their internal clocks have different offsets and drifts relative to each other. For example, video frame rate may be 25 per second, while GPS output may come 4 times in a second. Algorithms must be able to perform the necessary interpolation taking into account the necessary biases and drifts.

Insect Sensors: As discussed before, many insects possess unique sensing abilities, and drones have been drawing inspiration from them. Some of these are discussed here.

Optic Flow (Compound Eye): Bees measure distance using optic flow, i.e., the amount that an image appears to move as the position of the observer moves. Nearby things produce more optic flow than distant objects. All of us have observed how from a moving train, closeby scenes seem to pass by so quickly while the distant landscape is quite stable. With proper calibration, the optic flow information can be used for altitude control, terrain following, and collision avoidance, to name a few. (See Figure 8). Special optic flow sensors are being explored for real-time operations.

Ocelli: Some insects have small, simple eyes with no elaborate retina that are good enough for them to perform their tasks. For drones, a simple camera may reduce computation overheads, for example for sensing horizon for flight stabilization (see [6] for details).

Halters: Halteres are small knobbed structures modified from the hind wings in flies. They vibrate during flight, and help the insect fly more stably. They work as gyroscopes, telling the insect about its body position during flight. Drones that battle with the noise and drift in MEMS sensors can benefit from this study to fly stably.

Other Sensors: Many sensors other than the bio-inspired ones find their usage in drone operations, particularly the military ones. Some of these are radiation sensors, pesticide sensors, poison sensors, etc. Most of them for drones are realized using MEMS technology.

Processing

Processing for intelligent drones can be divided into three categories, i) on-board processing by individual drones using own sensor data, ii) distributed processing by a group (swarm) of drones using data from few or all the members of the group, and iii) backend processing on a central server (or cloud) using data from multiple drones obtained over time and also auxiliary data as required.

Independent Processing On-board

Small drones cannot carry large compute power due to restrictions on size, power, and weight (SWAP). This limits their capacity to run advanced algorithms on board. This motivates innovation of low-SWAP processors, and better algorithms with low time and space complexity.

Swarm Operations

While operating in groups (Figure 9), drones must periodically exchange data with team members. This brings about a few challenges. First, sharing of the communication channel. Multiplexing methods and channel access algorithms need to be decided for interference-free operations. Coding schemes must provide error resilience with least overheads. Newer swarm algorithms need to be designed to enable novel applications, and existing ones enhanced for better capability and less overheads.

Figure 9: Drone Swarms

Central/ Cloud Processing

Most of the heavy processing must be performed at a ground station, server, or cloud. Central processing is also essential for longer-term spatio-temporal inference, for example studying the movement patterns of a suspect over many days or months in different parts of the city.

Data can be transmitted to the server in real-time or can be retrieved from on-board storage after the mission. In the former case, datalink ranges, bandwidth, and/or affordable transmission power will define bounds on the amount of data transferred. Data compression is subject to encoding complexity, acceptable loss, and acceptable delays. In the latter case, onboard storage capacity will limit the amount of data. One must also note that in the absence of live data on ground station, course correction is possible only with drones' on-board

Intelligence

Possibilities of inference with spatio-temporal data fusion are endless, with practically no limit on computational resources. However, there is an urgent need for data fusion models that can bring multi-modal data to a common frame of reference and draw actionable intelligence from them.

Primary Software Components

Software is the real brain of intelligent drone systems, with many of its sub disciplines playing different roles; most significant of these as listed in Table-1.

Safety Concerns

Intelligence is aimed at taking autonomous decisions. The general artificial intelligence that aims to meet the scale and fluidity akin to the human brain is still very far away; however, even the narrower artificial

Table-1: Intelligent Drones: Software Disciplines

Discipline	Examples
Computer Vision	Monocular and stereo vision, scene understanding, target detection and recognition
Photogrammetry	Geolocalisation, measurement of area, sizes, distances
Signal processing	Estimation, filtering, smoothing, extracting weak signal from noise
Artificial Intelligence, Machine Learning, Deep learning	Supervised learning to classify sounds, species, unsupervised learning to identify clusters, Expert Systems
Speech-to-text	Audio commands, Eavesdropping
Natural Language Processing	Extraction of specific context from the text heard or read
Data Fusion	At the lowest level, alignment and correlation of data, going up to statistical multisource-multitarget information fusion

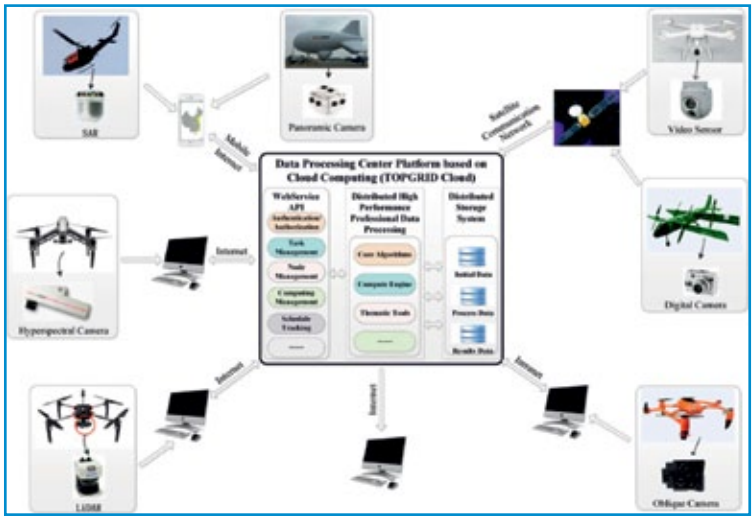
intelligence that refers to machine learning is also based on probabilistic models. The fields of aeronautics and defence demand provable performance in order to protect property and lives. This brings in a unique challenge for intelligent drones i.e., testability and provability of such systems.

In India, the government has issued many guidelines for drone fights. A tradeoff is needed to encourage innovation and progress in this field while addressing all the safety concerns.

Conclusions

The present military situation recalls previous epochs in which breakthroughs in hardware - aircraft carriers, jet aircraft, tactical missiles, nuclear weapons - have led to revisions of military doctrine. The newer revisits to the doctrine have largely been influenced by breakthroughs in computer software and information technology. Drones had until now been playing a passive surveillance role. While both artificial intelligence and drones have their key roles to play, it is the integration of the two that is enabling applications and capabilities that were not even imagined before. It is intelligent drones that shall drive the next radical revision to military strategy. Intelligent drones shall also play key roles in peacetime operations and in various applications of social benefits.

Many technical challenges must be overcome for making intelligent drones a reality. The research frontiers are calling upon the youth to innovate and lead the society into this exciting world.



Both graphics above courtesy researchgate.net

1st 6 J-10CE's received by PAF

On 11 March 2022, Prime Minister Imran Khan inspected the J-10CE fighter after their formal induction into Pakistan Air Force at Kamra Base.

(Photos: PakPMO and watermarks on photos)

1st upgraded Chinook delivered to Spain

The first remanufactured CH-47 Chinook helicopter was delivered to the Spanish Army at a ceremony held at the headquarters of the Spanish Army Airmobile Forces in Colmenar Viejo, Madrid. The aircraft is the first of 17 that will modernise the Spanish Chinook fleet, upgrading their existing CH-47D-model aircraft to the newer CH-47F model. The CH-47F features a digital automatic flight control system, common avionics architecture system and advanced cargo handling to meet the Spanish Army's modernisation needs for increased operational capacity, while ensuring interoperability with allied nations.

Additional MH-47G Block II Chinooks for US Army

Boeing has extended its partnership with the US Army Special Operations Aviation Command (USASOAC) with an order for six additional MH-47G Block II Chinook helicopters. The award, valued at $195 million, brings the total number of MH-47G Block II aircraft under contract with the USASOAC to 36. The upgraded MH-47G Block II Chinook features improved structure and weight reduction initiatives that increase the aircraft's performance and efficiency, allowing for extended lift and range.

Argentina orders Saab RBS 70 NG

Saab has received an order for deliveries of the short-range air defence systems RBS 70 NG to the Argentine Armed Forces. The Argentine Navy has been a user of the RBS 70 since 1984 and is now upgrading to the latest RBS 70 NG. The contract entails a further expansion of the country's usage of the RBS 70 NG system to the Air Force and to the Army. The RBS 70 NG systems, training simulators and missiles delivered, will therefore be used by the Argentine Army, Navy and the Air Force. RBS 70 NG is the latest iteration of Saab's short-range ground-based air defence system. With this order five nations have signed contracts for RBS 70 NG, including the Czech Republic, Brazil and Sweden.

Saab unveils deployable 5G Network 'DeployNet'

Saab is launching a state-of-the art, ruggedised, 5G communication system for military and crisis operations. DeployNet, locally developed by Saab in the UAE. A key fundamental for efficient command and control in military and crisis operations is communication. DeployNet provides a scalable 5G/LTE wireless network for the most challenging environments, offering high-capacity bandwidth for today's missions that rely on a multitude of information sources, sensors and user interaction. The compact system, underpinned with robust cyber security, can be deployed rapidly, enabling high-capacity bandwidth in geographically remote areas, or reinforcement of damaged or limited local networks.

Falcon 900LX selected by UK MoD

Two Dassault Falcon 900LX business jets will enter service with the Royal Air Force, providing VIP transport for senior defence and government officials. Due to begin operating this summer, they will replace a fleet of four BAe 146 aircraft, upgrading range capability and substantially reducing operating expense, fuel consumption and emissions.

Serbian Air Force is a new C295 operator

The Serbian Ministry of Defence has ordered two Airbus C295s and therefore the Serbian Air Force and Air Defence joins the family of C295 becoming the 36th operator worldwide. The two aircraft, in transport configuration, will be equipped with the modern avionics suite Collins Aerospace Pro Line Fusion and will contribute to enhance the air transport capabilities of the Republic of Serbia. Deliveries are expected to commence in late 2023.

Philippine DND for 32 Black Hawk's

PZL Mielec, a Lockheed Martin company has signed a contract award with the Philippine Department of National Defence (DND) to manufacture 32 additional S-70i Black Hawk utility helicopters for the Philippine Air Force. Delivery of all 32 aircraft by 2026 will dramatically increase the operational capacity of the Philippine Air Force to perform search and rescue missions, humanitarian assistance and disaster relief, and troop transport across the archipelagic country.

The Philippine Air Force's 205th Tactical Helicopter Wing will receive all 32 aircraft in a utility configuration. Each aircraft will be equipped with a fully integrated digital cockpit with four axis coupled flight director, color weather radar, integrated vehicle health monitoring system (IVHMS), cabin troop seats, and a 9,000-pound (4,082 kg) cargo hook.

Thales to equip German Navy NH90 with Flash Sonics Sonars

For the first time, the German Navy will rely on Thales to equip its NH90 Multi Role Frigate Helicopter (MRFH) with FLASH SONICS. The FLASH system (Folding Light Acoustic System for Helicopters) is currently the leading dipping sonar on the international market and has become the benchmark system for the world's major navies. The key benefits of this low-frequency wideband sonar include long-range detection and low false alarm rates in open ocean as well as littoral waters. Associated with an active and passive sonobuoy processing system, FLASH provides an 'unrivalled' anti-submarine warfare capability.

Safran SBH contract to support Arrano engines

All Nippon Helicopter (ANH) has signed a Support-By-the-Hour (SBH) contract with Safran Helicopter Engines to support Arrano engines powering its brand new Airbus H160 helicopter. This contract formalises a MRO (Maintenance, Repair and Overhaul) and service agreement supporting the two engines of the helicopter. This is the first-ever SBH contact signed for the Arrano. This contract will be managed locally by Japan Aerospace Corporation and supported by Safran Helicopter Engines Japan, supporting more than 110 helicopter operators flying in Japan.

Safran and Bell to collaborate on SAF

Safran Helicopter Engines and Bell Textron have announced a collaboration initiative to explore technical performance and economic impacts of sustainable aviation fuel (SAF) on the Arrius 2R-powered Bell 505. A single, dedicated Bell 505 aircraft will conduct flights solely with the use of blended SAF. Both Bell and Safran Helicopter Engines will evaluate engine and aircraft performance data to better assess the collateral benefits associated with the incorporation of SAF, a significant tool being used to reach industry carbon reduction objectives.

With all its engine range already certified to operate on up to 50% SAF, Safran objective is to certify in the coming years the use of 100% SAF, which can potentially result in carbon lifecycle emissions reductions by up to 80%. In 2021, Safran conducted ground test campaign for a Makila 2 running on 100% SAF, and followed this with successful flight tests.

Hensoldt equips German C-130 Hercules with MILDS

In the course of the acquisition of three Lockheed C-130J-30 and KC-130J "Hercules" aircraft each, the German Bundeswehr has decided to equip all aircraft with HENSOLDT's latest generation of defence sensor technology. With MILDS Block 2, HENSOLDT is supplying a total of 35 sensors (five per aircraft and five units for lab use) to Danish company Terma, which is managing the integration of the systems at Lockheed Martin through Terma Inc. The contracts, with a scope of 2.9 million euros, were signed in 2020. So far, 20 sensors and the ordered desiccant-kits have already been delivered. By January 2023, the remaining 15 sensors will be delivered.

France for General Atomics EMALS

France has requested to buy one Electromagnetic Aircraft Launch System (EMALS), 2 launcher configuration; and one Advanced Arresting Gear (AAG), 3 engine configuration. Also included are land-based testing and test spares; shipboard install; testing and certification support; shipboard spares; peculiar support equipment; government furnished equipment; multi-purpose reconfigurable training system; operator and maintainer training; integrated electronic technical manuals; drawings and interface control documents; technical assistance; contractor engineering technical services; and other related elements of logistical and program support. The estimated total cost is $1.321 billion.

GA-EMS and Boeing to develop 300kW-class HELWS prototype

General Atomics Electromagnetic Systems (GA-EMS) and the Boeing team has been awarded a US Army Rapid Capabilities and Critical Technologies Office (RCCTO) contract to develop a 300kW-class solid state Distributed Gain High Energy Laser Weapon System. Delivery will be a 300 kW-class distributed gain laser with an integrated Boeing beam director. The objective of this contract is a demonstration of the design.

Dassault in 2021

In a context of a new crisis related to the war between Russia and Ukraine, the Board of Directors chaired by Mr. Éric Trappier approved the 2021 statement of accounts. For Dassault Aviation, 2021 was a good year for both civil aviation and military sectors with an exceptional order intake of 100 aircraft (49 Rafale and 51 Falcon) and net sales of EUR 7.2 billion. In addition, the Group delivered 30 Falcon (compared with the guidance of 25) and 25 Rafale (consistent with the guidance).

In the military sector, 2021 saw marketing efforts for the Rafale succeeding, leading to the order for 49 new Rafale (Egypt 30+1, France 12, Greece 6) and 12 pre-owned Rafale (Greece). The backlog as of 31 December 2021 now includes 86 new Rafale (46 Export, 40 France).

- The signing of a contract for 80 Rafale for the United Arab Emirates.
- The purchase by Croatia, following an international call for tenders, of Rafale previously in service with the French Air and Space Force. Alongside this order, Dassault Aviation signed a contract to provide associated support for the fleet ordered.
- The delivery of 25 Rafale to our export customers, Qatar and India,
- The continuation of development work on the Rafale F4 standard,
- The award by France of a new vertically integrated support contract (Balzac) for the support of its Mirage 2000. The other vertically integrated contracts signed with France for the Rafale (Ravel) and the ATL2 (Ocean) are continuing, with performance exceeding the contractual targets.
- For the FCAS, an area in which Dassault Aviation is the leader with the New Generation Fighter demonstrator, the initial work phases on the demonstrators (Phase 1A) continued in 2021 and will be completed in first semester 2022. Joint Concept Studies (JCS) are ongoing. The next phase of the work (Phase 1B) has not been awarded no agreement having been found with Airbus Defence & Space.

Rafale success has also been confirmed in early 2022 by signature of a 42 (6+36) Rafale contract for Indonesia for which the T0 is awaited and the authorisation by the Greek parliament of the signature a contract for an additional 6 new Rafale. Regarding the Eurodrone, on 24 February 2022, Airbus GmbH as prime contractor and on behalf of the 3 main contractors, Airbus Defence and Space S.A.U in Spain, Dassault Aviation in France and Leonardo S.p.A. in Italia and the Organisation for Joint Armament Cooperation (OCCAR) representing the first 4 customers (Germany, France, Italy and Spain) signed the Eurodrone contract relative to the development, the production and the 5 year maintenance of 20 systems. Dassault Aviation will be in charge of flight control and mission communication systems, (with Thales).

For the multi-mission Falcon, work continued on "Albatros" (surveillance and maritime response aircraft on a Falcon 2000LXS platform) and "Archange" (electronic warfare aircraft on a Falcon 8X platform). The sixth Falcon 2000 for the Japan Coast Guard was delivered. Furthermore, commercial prospections are ongoing. In the civil aviation segment, 30 Falcon were delivered (for guidance of 25) and 51 Falcon were ordered in 2021. This increase in activity is due to the recovery of business aviation market and expansion of the product line with the Falcon 6X and Falcon 10X.

In the continuity of the elapsed year, Dassault's objectives for 2022 are:

- Rafale: to perform contracts, secure the first advance on the contracts signed and continue business development.
- Military developments: to continue the programs under way and prepare future Rafale standards.
- Falcon: to support the market recovery and boost sales.
- Falcon 6X: to ensure a successful entry into service and ramp up mass production.
- Falcon 10X: to adhere to the development schedule for an entry into service in late 2025.
- Civil and military aircraft support and availability: to maintain the highest standards.
- Energy transition: to pursue the R&T in conception.
- Make in India: to continue ramping up the activities transferred to DRAL.
- New Generation Fighter: decide on Phase 1B.
- Eurodrone: to perform the contract.

Updates from Saab

Saab and Safran SBH contract for Swedish AW109 engines

Safran Helicopter Engines and Saab have renewed their agreement to support Arrius 2K2 engines powering the Leonardo AW109 operated by the Swedish Armed Forces. This Support-By-the-Hour (SBH) contract formalises a 9-years MRO (Maintenance, Repair and Overhaul) and services agreement supporting a total of 45 engines. This contract will be managed by Safran Helicopter Engines Germany GmbH, which supports more than 300 operators flying in Germany, Scandinavia, Central and Eastern Europe, Russia and Central Asia, with more than 2,000 engines.

SBH is Safran Helicopter Engines' support-by-the-hour programme. It makes engine operating costs predictable, eliminates cash peaks, allows flexibility for scheduled and unscheduled MRO coverage. It now covers 50% of Safran Helicopter Engines' customer turbines' flying hours. SBH and Health Monitoring are part of EngineLife Services, Safran's range of solutions for helicopter engines.

Saab launches a new mobile high-mast solution for Giraffe 4A

Saab has launched a new mobile high-mast solution with the Finnish partner Conlog Oy, for fast and efficient deployment in order to meet modern threats of low altitude such as cruise missiles and Unmanned Aerial Vehicles (UAVs) in the battlefield of today. The new mobile high-mast solution for Giraffe 4A is designed to meet customer needs and handle forest environments with high obstacles as well as urban surroundings with large buildings disrupting the radar's line of sight.

Giraffe 4A is a multifunctional medium to long-range AESA radar, fully adaptable for different missions with simultaneous capabilities. It provides an all-weather coverage against air targets from low, slow and small targets (UAVs), to fast moving fighters as well as hyper- and supersonic missiles, RAM targets and detection/tracking of jammer strobes. Giraffe 4A can support and designate a variety of GBAD solutions and missiles systems with its surveillance capabilities. With over 60 years of experience in building radars, this new solution will be a tactical benefit of flexibility for units in the field of operation. The system gives a high accuracy and update rate combined with 360° monitoring of the air volume as well as advanced stop and stare capabilities.

Saab receives further order on heavyweight torpedo system

Saab has received an order from the Swedish Defence Material Organisation (FMV) for the next phase of the life extension programme of Torpedo 62. The order value is SEK 145 million and deliveries will take place by the end of 2023. The order includes pre-studies and engineering which incorporates subsystem prototypes for improvements of the current torpedo.

The life extension programme for the Swedish Navy's heavyweight torpedo was first signed in 2020. Torpedo 62 is a heavyweight torpedo system for surface and underwater targets. Torpedo 62 is equipped with an advanced propulsion system with high capacity and long endurance, combined with an advanced target seeker, developed for the Swedish Navy's operational area.

Saab to deliver upgrade for Hungarian Gripens

The Hungarian Government Commissioner Office responsible for defence development and the Swedish Defence Materiel Administration (FMV) have successfully completed the negotiations for the MS20 Block 2 capability upgrade to the Hungarian fleet of Gripen fighter aircraft. Saab will deliver the upgrade.

The MS20 Block 2 upgrade brings a number of improvements. It greatly increases both Gripen's combat and communication capabilities, as well as access to a wide range of weapons that can be integrated on Hungarian Air Force (HunAF) Gripen fighters. Sensor capability is being enhanced by a radar upgrade to the PS-05/A Mk 4 which means that the air-to-air target tracking range as well as the performance increases significantly. This allows better detection capability of small air- to-air targets, improved clutter suppression, and brings growth potential for further developments in the air-to air and air-to-ground modes.

The MS20 Block 2 upgrade for HunAF Gripen fleet also enhances the communication capabilities by enhancing Link16 (NATO Data link) functionality and updated voice communication to the latest NATO secure communication standard. Capability to identify coalition aircrafts will be also improved by introducing the latest Identification Friend or Foe (IFF) NATO Mode 5.

This upgrade will allow Hungary to choose from a wider selection of weapons to fit to their Gripens: IRIS-T - infrared Within Visual Range (WVR) Air to Air missile, GBU-49 - modern Air to Ground laser guided bomb and Meteor – an advanced, long-range, radar-guided, BVRAAM that is superior to other missiles of its type.

Over 150 million people in five countries on three continents rely on Gripen C/D fighters to protect their sovereign air space and ensuring their independence.

Next generation Carl-Gustaf round ordered by Sweden

Saab has received orders from the Swedish Defence Materiel Administration (FMV) for deliveries of both the new High Explosive round and Fire Control Device for the recoilless Carl-Gustaf rifle. The order values are approximately SEK 300 million and SEK 65 million respectively and deliveries will take place during 2022-2023. The ammunition in this order will be used by the Swedish Armed Forces. The new High Explosive round is programmable and has the ability to communicate with the new Fire Control Device. This means that the Carl-Gustaf operator will be able to quickly configure a chambered round.

Saab in TactiCall order from Royal Norwegian Navy

Saab has signed a contract with the Norwegian Defence Material Agency, to provide a complete communication system, TactiCall ICS, on board of three different ship classes for the Royal Norwegian Navy. The Norwegian Defence Material Agency (NDMA) has selected TactiCall Integrated Communication System (ICS) to replace the existing communication system for both internal and external use on-board, including multi-level secure communication – unclassified, restricted NATO secret and national secret communication channels. TactiCall will be integrated on the following ship classes: Mine Countermeasure Vessels (MCM), the Skjold-class Corvettes and the Coast Guard Vessel (CGV) Svalbard. Deliveries will be from 2021 to 2024 across seven of these Norwegian ships.

Boeing/Saab's T-7A Red Hawk

Next generation of pilot training

During Dubai Air Show 2021, Thom Breckenridge, Boeing's Vice President, Bombers and Fighters International Business Development, discussed the T-7 advanced pilot training system with reporters.

The T-7A Red Hawk is an all-new advanced pilot training system designed for the US Air Force that will train the next generation of fighter and bomber pilots for decades to come. In September 2018, the US Air Force awarded Boeing a $9.2 billion contract to supply 351 advanced trainer aircraft and 46 associated ground based training simulators. The US Air Force's T-7A Red Hawk programme is arguably the world's first digitally-native aircraft programme, ushering in a new era of aircraft design and production that is breaking the norms of typical new-start DoD programs of record.

During the media briefing to reporters, Thom Breckenridge, Boeing vice president, Bombers & Fighters, International Business Development, said the T-7 was a new advanced pilot training system that included ground-based training designed together from the start, and engineers applied model-based engineering and advanced manufacturing and testing techniques to move from concept to first flight in just 36 months. "Compared to traditional aircraft development programmes, T-7A experienced a 75% increase improvement in first-time engineering quality, an 80% reduction in assembly hours and a 50% reduction in software development and verification time," he stated.

Breckenridge explained that executing the US Air Force contract for the T-7A Red Hawk was Boeing's top priority right now and would strengthen the ability to ultimately serve the international market. "T-7 will be a franchise programme for much of this century, and beyond the current US Air Force contract, we see potential global market opportunities of up to 2,600 aircraft plus ground-based trainers and advanced simulation technologies," he further stated.

Boeing says that customers will benefit greatly from the T-7's advanced pilot training system, providing real-as-it-gets simulation, interactive classroom lessons, computer-based training modules, adaptive training that adjusts to students' needs, and a complete suite of instructor tools–for optimum results on the ground and in the "classroom in the sky." The T-7A's design includes provisions for growth as requirements evolve for additional missions.

Safran reports full-year 2021 results

Expecting further improvement in 2022, in line with 2025 growth trajectory

CEO Olivier Andriès stated, "2021 was an important year for Safran, marked by significant operational and financial progress. As the market recovers from its low point in Q1 2021 we delivered solid margin and cash performance, exceeding our outlook. We generated robust commercial orders across our businesses and gained traction from Rafale export programmes. Safran is well placed to benefit from the positive trends in both aftermarket and original equipment as narrowbody traffic returns to pre-crisis levels by end 2022. In 2022 we see real momentum for sustainable growth, and are ready to raise OE production rates and accelerate the pace of investment for decarbonisation. We intend to continue reinvesting capital from divested activities into complementary, bolt-on acquisitions with growth potential."

Revenue: The global narrowbody capacity in 2021 has been uneven across geographies but increased throughout the year. In 2021, narrowbody ASK were at 63% (on average) of 2019, with Q4 2021 at 75% of Q4 2019. 2021 revenue amounted to €15,257 million.

Propulsion: Slight decrease in sales by (1.1)% mainly due to civil OE volumes (high thrust and CFM56 engines). In 2021, combined shipments of CFM engines reached 952 units (845 LEAP and 107 CFM56), compared with 972 in the prior year. Military engine deliveries were up driven by Rafale. Civil aftermarket increased by 7.1% (in USD) thanks to a higher contribution from services contracts and to a lesser extent from spare parts sales for CFM56. Helicopter turbine activities registered a low single digit growth thanks to services, despite lower OE (Arrius and Makila families). Q4-21 sales increased by 13.7% due to civil aftermarket revenue, up 54% compared to Q4 2020 and up 32% compared to Q3 2021 (as a reminder civil aftermarket: (53)% in Q1-21, +55% in Q2- 21, +44% in Q3-21).

Safran and Thai Aviation Industries reinforce partnership

Safran Helicopter Engines and Thai Aviation Industries have signed a contract to support Arrius 2B2Plus of the Royal Thai Air Force (RTAF), and have renewed the existing one intented for their Makila. Powering their H135 and H225M helicopters, over 12 Arrius and 24 Makila engines are now covered by Safran's Global Support Package (GSP). Since 2017, this agreement has proved its efficiency to satisfy RTAF's requirements for optimum availability during their operations.

Safran and ST Engineering to study SAF in helicopter engines

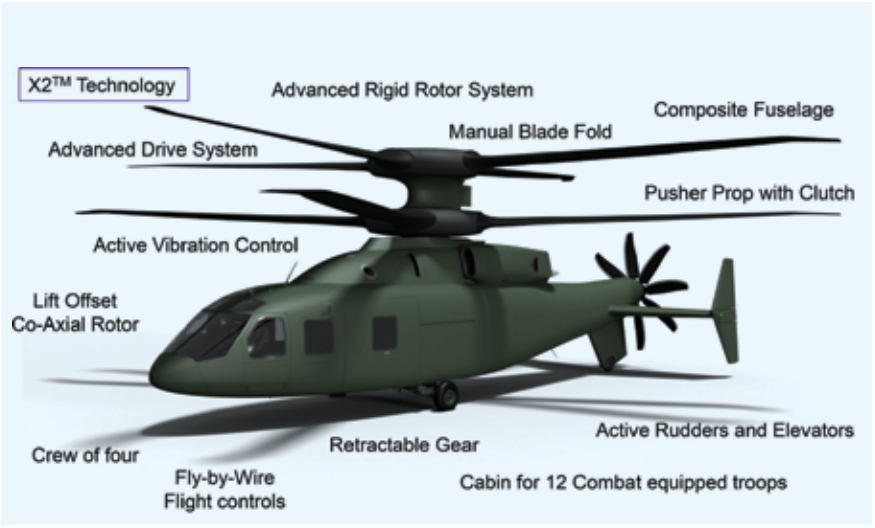
Safran Helicopter Engines and the commercial aerospace business of ST Engineering signed a Memorandum of Understanding (MoU) to study the use of Sustainable Aviation Fuel (SAF) in helicopter engines, with the objective of assisting helicopter operators in their transition to the use of SAF. All Safran's helicopter engines are currently certified to operate on up to 50% SAF. The objective of the collaboration is to also certify in the coming years the use of 100% SAF, which can potentially result in carbon emission reduction by up to 80%.

Lockheed Martin Sikorsky-Boeing DEFIANT progresses

The Lockheed Martin Sikorsky-Boeing DEFIANT has successfully completed FLRAA mission profile test flights, including confined area landings and low-level flight operations. These flights validate DEFIANT's relevancy to the Army's mission, providing agility at the objective (also known as the "X"), and increased survivability, all while reducing pilot workload.

SB>1 DEFIANT is the technology demonstrator proving out transformational capabilities for the DEFIANT X weapon system, the Sikorsky-Boeing team offering for the US Army's Future Long-Range Assault Aircraft (FLRAA) competition as part of the Army's Future Vertical Lift programme. DEFIANT X will enable crews to fly low and fast through complex terrain, where Army aviators spend most of their time. It will extend capabilities of Army Aviation on the modern battlefield – and is designed to fit in the same footprint as a BLACK HAWK. With DEFIANT X, the US Army will deliver troops and cargo in future combat at twice the range of the current fleet.

DEFIANT X incorporates Sikorsky X2 Technology to operate at high speeds while maintaining low-speed handling qualities. This critical capability provides pilots with increased maneuverability and survivability in high-threat environments, allowing them to penetrate enemy defenses while reducing exposure to enemy fire. DEFIANT X's X2 coaxial rotor system and pusher prop allows for a high degree of maneuverability in and around the objective which is also directly linked to survivability.



News from General Atomics

GA-ASI Avengers equipped with Lockheed Martin Legion Pods tested

In late 2021, General Atomics Aeronautical Systems, Inc. (GA-ASI) used two company-owned Avenger Unmanned Aircraft Systems, each equipped with a Lockheed Martin Legion Pod, to send long-range air threat data captured passively and fused by an advanced sensor algorithm to a Command Center. In the two-hour flight, the Avengers flew over the high desert of southern California. During the flight, Legion Pod's IRST21 infrared search and track system detected multiple fast-moving aircraft operating in the area. On-pod Lockheed Martin fusion software blended the sensor data

This fusion technology was previously tested in F-15-equipped Legion Pods and datalinks at the Northern Edge operational exercise. Legion Pod is a proven long-range passive IRST sensor on multiple platforms including two types of Avenger UAVs.

France for MQ-9 follow-on contractor logistics support

The Government of France has requested to buy follow-on Contractor Logistics Support to include contractor provided MQ-9 aircraft components, spares and accessories; repair and return; software and software support services; simulator software; personnel training and training equipment; publications and technical documentation; US Government and contractor provided engineering, technical and logistical support services; and other related elements of logistical and program support. The estimated total cost is $300 million.

GA-ASI completes series of system level tests for Protector

General Atomics Aeronautical Systems successfully completed key system-level tests for the new Protector RG Mk1 Remotely Piloted Aircraft (RPA). The Protector is the UK Royal Air Force's version of the MQ-9B SkyGuardian, which is GA-ASI's latest model of RPA and is on track to become the world's first certified Medium-altitude, Long-endurance (MALE) RPA. The first Protector is expected to complete its test and evaluation programme late 2022 and arrive in the UK in 2023.

USMC acquires more MQ-9A Reapers

General Atomics Aeronautical Systems completed the transfer of two MQ-9A Reaper Block 5 Unmanned Aircraft Systems (UAS) to the US Marine Corps late 2021. The two aircraft have been operated by the USMC since 2018 under a Company Owned/Company Operated (COCO) lease agreement in support of an Urgent Operational Need. The Reapers represent the first increment of the Marine Air-Ground Task Force (MAGTF) Unmanned Aircraft System (UAS) Expeditionary (MUX) Programme of Record (POR). The transfer of aircraft includes two Ground Control Stations and associated support equipment.

The MQ-9A Block 5 has endurance of over 26 hours, speeds of 220 KTAS and can operate up to 45,000 feet. It has a 3,850-pound (1,746 kg) payload capacity that includes 3,000 pounds (1,361 kg) of external stores. It provides a long-endurance, persistent surveillance capability with Full-Motion Video and Synthetic Aperture Radar. The MQ-9A Block 5 is equipped with a fault-tolerant flight control system and triple redundant avionics system architecture.

U-2S Dragon Lady : The Electronic Pilot

(Photo: Keith Heywood)

On 15 December 2020, Artificial Intelligence (AI) driven algorithms controlled sensor and navigation systems on a United States Air Force (USAF) Lockheed Martin U-2S Dragon Lady Reconnaissance aircraft in a flight test. The service says that this is the first time that artificial intelligence has been "safely" put in charge of any United States military system and appears to be the first time it has been publicly utilised on a military aircraft. The test, involved a U-2S from the 9th Reconnaissance Wing at Beale Air Force Base in California.

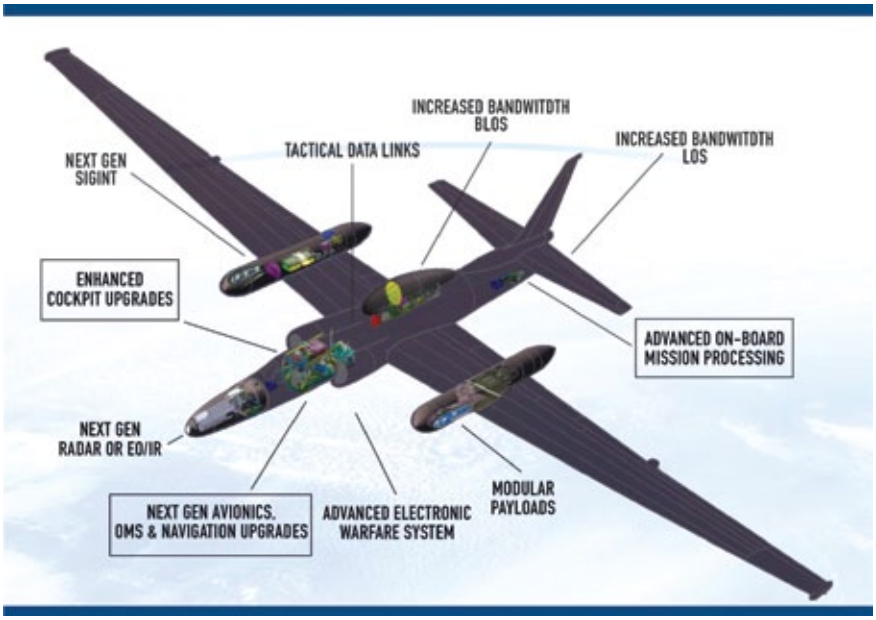
The Air Force has dubbed the AI software package as ARTUμ, in reference to the iconic droid from the Star Wars universe, who serves as a sort of robotic flight engineer and navigator. "ARTUμ's ground breaking flight culminates our three-year journey to becoming a digital force," Assistant Air Force Secretary Will Roper said in a statement. "Putting AI safely in command of a US military system for the first time ushers in a new age of human-machine teaming and algorithmic competition. Failing to realise AI's full potential will mean ceding decision advantage to our adversaries." "Call sign 'Artuμ,' we modified world-leading μZero gaming algorithms to operate the U-2›s radar,» Roper wrote in his tweet about the test. «This first AI co-pilot even served as mission commander on its seminal training flight!»

The μZero algorithm, developed by AI Research Company 'DeepMind' has been used by computers to play chess, Go, and video games in the past, "without prior knowledge of their rules," Roper further explained in a piece he wrote for Popular Mechanics about this test. The U-2 Federal Laboratory helped integrate the modified ARTUμ version of this software package onto the U-2S reconnaissance platform. And it is enabled by a publicly available, Google-developed system called Kubernetes, which allows the AI software to be ported between the plane's on-board computer systems and the cloud-based one it was developed on.

In Popular Mechanics, Roper described the flight test as follows: "Our demo flew a reconnaissance mission during a simulated missile strike at Beale Air Force Base. ARTUμ searched for enemy launchers while our pilot (call sign "Vudu") searched for threatening aircraft, both sharing the U-2's radar. With no pilot override, ARTUμ made final calls on devoting the radar to missile hunting versus self-protection. Luke Skywalker certainly never took such orders from his X-Wing sidekick!"

"Like a breaker box for code, the U-2 gave ARTUμ complete radar control while 'switching off' access to other subsystems. Had the scenario been navigating an asteroid field—or more likely field of enemy radars—those 'on-off' switches could adjust. The design allows operators to choose what AI won't do to accept the operational risk of what it will. Creating this software breaker box—instead of Pandora's, has been an Air Force journey of more than a few parsecs". Roper said the AI was trained against an opposing computer to look for oncoming missiles and missile launchers. For the purposes of the initial test flight, the AI got the final vote on where to direct the plane's sensors.

The radar referred to is likely to be the latest iterations of the Advanced Synthetic



The upgrades, highlighted in boxes above, will prepare the U-2 for additional modernisation efforts that will provide a quantum leap in capability for the warfighter and a bridge to capabilities needed in the future battlespace. (Image: LM)

Aperture Radar System-2 (ASARS-2) all weather day and night high resolution radar imaging system, which Dragon Ladies routinely carry and features two sideways-looking electronically-scanned array radar antennas on either side of a specially designed nose module. ASARS-2 can operate in search and spot modes against moving and stationary targets. In moving target indicator mode, the view of moving targets is presented against a Synthetic Aperture Radar (SAR) background or a cartographic background. Operation in spot mode against stationary targets provides a higher degree of detail and finer target discrimination. A recorder for the ASARS-2 is installed in the equipment bay forward of the main landing gear well. Data from the ASARS-2 is downloaded via a real-time wideband data link to the TR-1 ground station, TRIGS-1, supplied by Lockheed Martin. Upgraded Raytheon ASARS-2A radar has been developed which has an increase in coverage, more capable spot mode and enhanced ground moving target indicator, with a new on-board processor.

U-2s also regularly carry powerful Senior Glass Signals Intelligence (SIGINT) suite that includes Senior Spear Communication Intelligence (COMINT) and Senior Ruby Electronic Intelligence (ELINT) payloads that can detect, categorise, and geolocate various emitters, including those from hostile radars, plus a formidable AN/ALQ-221 defensive electronic warfare suite. A new software package allows a Dragon Lady to update its mission systems in flight including the addition of new target recognition algorithms onto the aircraft. The fleet is equipped with Senior Year electro-optical reconnaissance system (SYERS) sensor SYERS-2C supplied by Collins Aerospace.

Surveillance function is one that has already incorporated the use of AI to analyse complex data. An USAF programme called Project Maven sought to rapidly analyse reams of drone footage in place of humans. Google famously declined to renew its Maven contract following an internal revolt from employees who didn't want the company's algorithms involved in warfare. The company later released a set of AI principles that disallowed the company's algorithms from being used in any weapons system. In any case, AI in military application will take several decades to sufficiently mature.

Sayan Majumdar

(Photo: Keith Heywood)

Amphibious ops for Dutch NH-90

Since the Dutch Helicopter Command (DHC) started its operations with the NH-90, the focus was on maritime missions in their role as NATO Frigate Helicopter (NFH). Stationed on multipurpose frigates, Ocean-going Patrol Vessels (OPV) or on one of the 2 Landing Platform Docks (LPD), they execute their sea based operations. These include amongst others, Surface Warfare (SuW), Anti-Submarine Warfare (ASW), counterdrug, replenishment at sea and Search and Rescue (SAR) duties. For these duties, the NH-90 can carry door mounted rifles and Mark46 torpedos.

Cougar capacity

However, due to earlier capacity constraints in the initial years of NH-90 operations, the TNFH amphibious tasks were taken care by the AS-532 U2 Cougar helicopters. Although the Cougars, which were in operations since 1996, had been taken out of service in 2011 because of Dutch defence cost cutting programmes, the defence staff decided to put them back into operations as the introduction of the NH-90 suffered from technical issues and delays. Next to the NH-90 programme, the introduction of the CH-47F MYII CAAS Chinook to replace the older CH-47Ds was also facing a delay in planning. This resulted in the revival of Cougar operations and although initially

mentioned as a temporary plan, finally 12 samples were fully operational with the so called "Wildcats" of 300 sqn. To remain on track with the new initiatives, DHC signed a Base Maintenance contract with Heli-One for maintenance and inspections support for the 12 helicopters and another five Cougars in storage.

The Cougars, based at Gilze-Rijen Air Force Base, were tasked for Medical Evacuation (MedEvac) and Special Operations Forces' (SOF) operations and later on equipped with float devices in their pontons, they also executed the amphibious tasks onboard navy vessels. Currently, with 20 NH-90s delivered (of which 1 was lost in an accident in 2020), and the CH-47F deliveries well underway, the Cougars come at age and approaching their end of career. This is also indicated with a new project to look for a replacement helicopter for SOF tasks, possibly in combination with Germany.

Guardian Defender 2022

Nevertheless, knowing the plans that the Cougars and their amphibious capacity will disappear, the NH-90's of 860 squadron based at Naval Air Station De Kooij, are now preparing to embed the amphibious task in their unit by 2024. For that reason, exercise "Guardian Defender 2022" was organised last February. During two weeks, two NH-90's were deployed to Deelen Air Force Base to train together with SOF on land base operations. The NH-90's dropped the SOF in "hostile" territory were they performed day and night operations before they were extracted by the helicopters to be dropped off at another location. During the intermediate days, the NH-90 performed replenishment flights in the area to bring in additional equipment and food to the SOF.

MASE

During the exercise Guardian Defender, the NH-90s were equipped with Modular Aircraft Survivability Equipment (MASE) protective systems which are essential during TNFH operations. Although the systems have been procured a few years ago from Terma, the NH-90s have been hardly seen in operations with these systems. MASE is a pod based system which contains an AN/ALQ-213 Electronic Warfare Management System (EWMS). It provides protection against Infra-Red (IR) seeking missiles and when the sensors detect an incoming threat it can initiate a variety of counter measures including release of chaff and flares from its dispensers. The modularity of the system provides flexibility for the NH-90 operators for future updates and renewal of components.

The NH-90 is mounted with two MASE pods, one on each side of the fuselage to provide a 360 degree covered protection. The pods give flexibility to operations as they only need to be attached when the mission requires and are interchangeable between the NH-90's.

It is expected that several exercises like Guardian Defender will be planned for further training of the NH-90 crews of 860 squadron, to take on the amphibious duties as planned per 2024.

Text and photos by Peter ten Berg

Baltic Air Policing (BAP and EBAP)

The Baltic Air Policing (BAP), is a rotational air defence role taken up by the North Atlantic Treaty Organisation (NATO) countries since the Baltic countries (Estonia, Lithuania and Lettonia) do not have the means to maintain their own air defence fighters on a 24/7 basis. For three to four months, NATO partners deploy their fighters to Ämari airbase in Estonia (ICAO: EEEI) or Šiauliai airbase in Lithuania (ICAO: EYSA). And in times of higher tensions, the eastern airbase of Malbork (ICAO: EPMB) in Poland is also used by NATO partners on rotational duty to protect the eastern NATO flank. The Malbork deployments are called Extended Baltic Air Policing (EBAP).

The Baltic Air Policing deployments are scheduled by NATO Allied Air Command based at Ramstein airbase (Germany) and the operational missions are controlled by NATO Combined Air Operations Centre

(CAOC) located at Uedem (Germany). The Baltic Control and Reporting Center (CRC) at Karmėlava (LT) directs the Baltic Air Policing aircraft to their targets.

Belgian Air Force

In 2004, the Belgian Air Force was the first NATO Air Force to participate in the NATO Baltic Air Policing (BAP) programme and 17 years later, the Belgians are the one of the two current BAP contributors. The other contributor is the Polish Air Force with F-16s at Siauliai airbase (ICAO: EYSA) in Lithuania. The Baltic Air Policing programme is under control of the NATO Allied Air Command based at Ramstein airbase (Germany). For the Baltic Air Policing, the overall control of the Baltic Air Space is coordinated from the Combined Air Operations Centre (CAOC) Uedem in Germany, where the whole of northern Europe is controlled.

The Belgian detachment is at 24 hours, 7 days a week readiness with two aircraft that can be airborne within fifteen minutes after the SCRAMBLE command has been issued. This is called the Quick Reaction Alert (QRA). Two aircraft that act as spare are kept at high readiness as well.

The first Belgian F-16s were acquired in the 1970/1980s but the airframes have been updated and refurbished throughout the years. The Lockheed Martin F-35 has been selected as a replacement and the first aircraft is expected to fly around 2024.

As weaponload, the aircraft is loaded with two AIM-120 AMRAAM anti-aircraft missiles (beyond visual range), two AIM-9 Sidewinder anti-aircraft missiles (within visual range) and one M61A1 six-barrel Gatling gun with some 500 bullets. Next to the radar, the targeting pod ('Sniper' Advanced Targeting Pod (ATP)) is used to zoom in on the target even before the pilots have visual sight on the target. With the targeting pod, it is easy to recognise the target and check for possible armament.

The F-16s are also equipped with flares, normally these are used as defence mechanisms against heat-seeking missiles. But these can also be used to attract the attention of the person inside of the cockpit of an intercepted aircraft. During nightflying operations, the Belgian pilots also use Night Vision Goggles (NVG) to amplify the remaining light in the sky.

When a 'rogue' aircraft has been intercepted a report is sent to the CRC and

a photo is made for confirmation. If the intercepted aircraft is posing a danger to other aircraft or is heading for a forbidden zone, like in case of an emergency; the F-16 is tasked to deviate this aircraft into another direction and for this purpose, flares can be considered as a very handy option.

In 99% of the intercepts, there is just an interrogation whereby the F-16s fly next to the aircraft and check the cockpit.

There are 3 kinds of Scrambles

- ★ ALPHA-SCRAMBLE: this is the real thing where the aircraft is launched in less than fifteen minutes
- ★ TANGO-SCRAMBLE: this is a training Scramble where the full Scramble is exercised, without any aircraft to be intercepted
- ★ SIERRA-SCRAMBLE: this is a training Scramble where the full Scramble is exercised, without a take-off.

Polish Air Force

On 25 November 2021, at the 31st Tactical air base Poznan-Krzesiny (ICAO:EPKS) , a solemn farewell to the soldiers of the 10th rotation of Polish Military Contingent 'Orlik 10' (PMC Orlik, 10th edition) took place..

The contingent numbers about 150 people. Its core consists of soldiers from the 31st Tactical airbase and four F-16 planes. The personnel were stationed in Šiauliai, Lithuania. For the F-16 crews from the 31st Tactical airbase, it was already NATO›s third Baltic Air Policing mission.

The most important task of the soldiers of the 10th rotation of the Polish Military Contingent Orlik was to intercept planes that has violated the airspace of Lithuania, Latvia and Estonia. The mission of the North Atlantic Alliance, as part of the military airspace surveillance of the Baltic States, was conducted on the basis of a rotating system of duty hours performed by other allied states since 2004. Polish aircraft flew for the first time at Baltic Air Policing in 2006.

At the Lithuanian airbase of Šiauliai on 30 November 2021, a symbolic handover of the key to the airspace took place as a change of military contingents carrying out the NATO Air Policing mission in the Baltic States. The airmen of the Polish Air Force, part of the Polish Military Contingent Orlik 10, took over the duties of colleagues from Flyvevåbnet (Danish Royal Air Force) and Força Aérea Português (Portuguese Air Force).

About 150 pilots, technicians, medical personnel, support teams, communications and other specialists, as well as 4 multi-role F-16 Block 52+ combat aircraft from the 31st Tactical Aviation Base were sent to Lithuania by the Polish Armed Forces. The commander of PKW Orlik 10 is Lt. Col. pil. Paweł Stajniak.

The Polish F-16s were acquired around 2002 and the first deliveries took place in 2006. And the Lockheed Martin F-35 has been selected to increase the strength of the Polish Air Force, the first should arrive around 2024.

Media Flight

On 25 January 2022, a media flight was organised by NATO Allied Air Command, the Polish Air Force, the Belgian Air Force and the Lithuanian Air Force. In the morning, an electronic briefing was started with the photo flight directors, the Polish F-16 pilots and the Lithuanian C-27 pilots at Šiauliai airbase while the Belgian F-16 pilots joined the briefing from Ämari airbase. During the briefing, the various formations, the timelines, the flight levels and the frequencies were discussed.

After the take-off, the Lithuanian C-27J transport aircraft flew towards a reserved airspace overhead northern Lithuania. Onboard were seven aviation reporters, securely attached to the floor. After some orbits, the Belgian F-16s joined up first for formation photos and break photos. Then the Polish F-16s joined for a flight with all four F-16s in various formations. After the formations of four, both Belgian and Polish flight leads would make a flight of two, while both flight leads had their national flags draped in the front of their cockpits. Then the Belgian F-16s departed back to Ämari airbase, while the Polish F-16s continued to fly during the beautiful sunset.

This photoflight was planned and coordinated by Sławek 'Hesja' Krajniewski, who organises similar commercial air-to-air photo opportunities in Poland.

Interview with the Polish DetCo for 'Orlik 10'

The Polish Detachment Commander (DetCo) is Lt. Colonel "Cobra" (his callsign), who started at the Polish Air Force academy in 1997. The Polish deployment 'Orlik 10' lasts from 1 December 2021 until 31 March 2022. Previously a combined Danish and Portuguese F-16 deployment was based here to protect the Lithiuanin airspace. With some 2230 flying hours in total and some 1560 hours in the F-16, Lt. Colonel "Cobra" leads the detachment of 130 persons of the Polish Air Force in Lithuania. Four Lockheed Martin F-16Cs (block 52+) are located in the Quick Reaction Alert (QRA) hangars of the

Šiauliai airbase in Lithuania. About half of the pilots are experienced pilots and the other half of the pilots are younger pilots, but fully Mission Qualified.

According to Lt Col "Cobra", the F-16s fly similar air defence tasks in Poland in various scenarios. "Here in Lithuania, they fly the same kind of missions". In March, The Polish Air Force staff accepted the proposal to go to Lithuania in December 2021 and 4 months prior to the deployment, the F-16s from Poznan airbase started with their preparations (documents and training). During and after this deployment, the Polish training syllabus has been enhanced with the lessons learned during this deployment. "Update the procedures, gain skill and experience not only by pilots but also all operational and logistical personnel '' are some of the lessons learned so far.

Next to air defence exercises with the Belgian F-16 based at Amari airbase (in Estonia), there was also some Close Air Support (CAS) exercises planned with Joint Terminal Attack Controllers (JTAC) from Lithuania and Latvia. The Polish F-16s fly their air policing missions always in pairs (two F-16s) and these F-16s are fully armed with the M61 six-barreled cannon, the AIM-9 Air Intercept Missile (Sidewinder) and the AIM-120 Advanced Medium-Range Air-to-Air Missile (AMRAAM).

Depending on the weather, some 40 missions are flown per month. Some missions are training and familiarisation missions (T-Scramble), some missions are reconnaissance missions.

When asked if this deployment met the expectations and if there were some improvements, Lt Col "Cobra" responded with "Yes, we are prepared as we trained, so not much needs to be improved". He expects more Polish deployments to the Baltic States, but that will depend on the situation. Lt Col "Cobra" stated, "Who kicks off the ball, has to bring it back", you have to report and gain knowledge to any situation.

Interview with one of the pilots in the photoflight

Captain "Pablo" (his callsign) started his career in 2007 at the Polish Air Force Academy and he has some 1050 flying hours. His role is QRA pilot/ commander and he with his wingman flew

the Polish F-16s with callsign POLKA1 and POLKA2.

As preparation for the photo flight, there was 1 briefing with the photo-planners, 1 briefing with the Belgian Pilots and 1 combined briefing was delivered to all participants (photo-planners, Polish pilots, Belgian pilots and Lithuanian C-27 pilots). The actual photo flight took place overhead Siauliai airbase, as the weather was favorable in that region of Lithuania.

As the Belgian F-16s were planned to arrive first with the C-27, the Polish F-16s arrived later for the photoshoot. And as the photoflight was overhead the Siauliai airbase, the Polish F-16s flew as long as they had enough fuel onboard to return to their base. Captain "Pablo" liked the deployment: "My team and the conditions (work, accomodation, sport, food and city). It was a very ambitious and well performed project. Our social media observers and media got crazy after this event.

Text and photos by Alex van Noye & Joris van Boven

Big thanks

- NATO Allied Air Command
- Polish Air Force
  - Poznan airbase, 31st airbase
  - Two F-16C
- Lithuanian Air Force
  - Siauliai airbase
  - C-27J for the photoshoot
- Belgian Air Force
  - Florennes and Kleine-Brogel airbase
  - Two F-16 MLU
- Sławek 'Hesja' Krajniewski for planning and performing the photoshoot

Air Marshal (R) Harish Masand says...

I learnt more than flying from them: VP Kala and "Babla Senapati"

Harvard at Yelahanka 2009 (Photo: Simon Watson)

During my flying training days in the 98th GD(P) Course, after finishing our flying on the HT-2 at PTE, Allahabad in September 1966, we were given a bit of leave to refresh our relations with near and dear ones and reached Air Force Flying College (AFFC) at Jodhpur in late October 1966. The intermediate stage was those days conducted at AFFC on Harvard Mk IV and Texan T-6G with minor differences between the two aircraft.

I was assigned to then Flight Lieutenant VP (Ved Prakash) Kala and my flying commenced on 14 November 1966. As per my memory, refreshed with the log book, I flew with a lot of instructors for some strange reason that I could not figure out then or even now. This included Flt Lt Ambady and Sharma, Sqn Ldrs Banerjee and M Paul apart from the Flight Commander, Sqn Ldr SS Ahuja and the ACFI, Sqn Ldr CK Bali. While this had its own advantages since I got to learn different things from different instructors, I suppose it also had its downside in the lack of continuity and the feeling of belonging to none.

Without doubt, VP Kala was an excellent instructor and very smooth on controls, a habit that I picked up and formulated my own technique on this quality as I gained more experience. He also gave me a great technique and some very useful tips on instrument flying which again stood me in good stead when I later started doing many things on instruments, including day/night aerobatics and sometime the entire air test profile till on finals, the latter with a safety pilot in the trainers that I flew so that they could take over if the situation was getting dangerous at any time, something that fortunately never occurred in my flying career. Due to such an instructor and what he taught me, I also found that recovery from unusual attitudes also became a cinch and saved me in many occasions when I inadvertently got into thick thunder clouds. Perhaps because VP Kala was an ex-transport pilot, he subtly passed me onto some ex-fighter pilots so that I could learn more about aerobatics and extreme handling of the aircraft from them.

Where VP Kala became very angry with me and almost stopped teaching me was after my night flying solo. VP did many and let me do many similar low overshoots wherein the aircraft just about touched or kissed the runway during the overshoot process. Without switching off, he asked me to go solo and do two or three low overshoots before landing. Unfortunately, the copycat

that I was, I did exactly what we had done in the dual sortie just before, kissing the runway during the go-around every time. Kala was in the runway controller's hut watching all this and while he did not say anything on the radio during my approaches and overshoots, he gave me a solid rocket after landing in the flight office during the debrief in front of all my co-pupils, well past mid-night. While he called me a cocky overconfident so-n-so, I actually lost a bit of my self confidence after that firing and it took me a little while before I recovered from this firing and its effect. Quite frankly, I did not sleep a wink that night. Perhaps, that was also one of the reasons why Kala did not put me up for a trophy check though I felt I was doing well and he felt that I had the confidence, if not over-confidence.

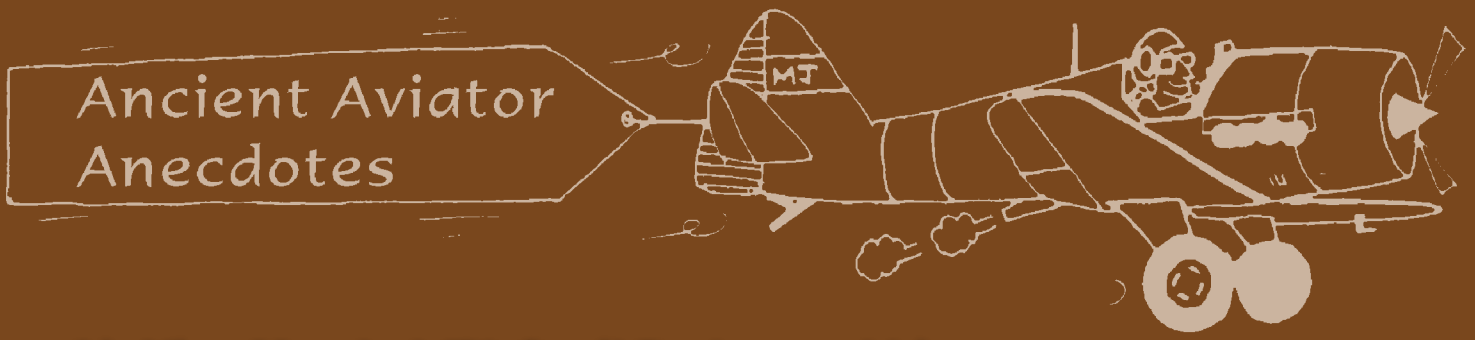
While I was in AFFC, my elder brother, "Sonny" Masand had come over on a transit flight as a Flying Officer on Packets. He had asked me about my instructor and how my training was going. After hearing everything, he had cautioned me to be careful because most ex-transport instructors tended to recommend their smooth flying pupils for the transport stream while most of the rough ones got fighters. Right or wrong, at least that was Sonny's experience and he tried to talk me into being a little rough on controls while flying. I don't think I needed to do that because, after the night flying incident, VP Kala had become somewhat disinterested in my progress and towards the end, he only asked me where I wanted to go. When I vehemently opted for fighters, he, without any discussion or contrary opinion/ advice, recommended me for fighters and I landed up in Hakimpet for the advanced stage of training.

However, apart from this and all he taught me, I would be ever grateful for what VP Kala specifically did before this incident in my initial solo sorties with a dual in between to check the progress when I was learning to do aerobatics and spins on the Texan. On 28 December 1966, he sent me for an aerobatics sortie with Wg Cdr "Babla" Senapati, who was just visiting AFFC from somewhere and perhaps needed to log some flying hours. After climbing to the required height, Babla Senapati, instead of aerobatics, first asked me to describe a figure of eight around the horizon. He then demonstrated what he meant by such manoeuvres by showing me how to do a high yo-yo above the horizon, a low yo-yo below the horizon and a figure of eight and then asked me to practice these for the next 10-15 minutes. All this was to be done without looking inside at the instruments purely by feel and seat of the pants to try and get the same attitude above and below the horizon in the same number of degrees of turn through coordinated movement of all three controls. It was only after he felt that I had understood the concept that he asked me to do some aerobatics and made comments so as to improve my performance. On the ground, in the debrief, Babla Senapati spent some extra time with me and explained how these practice manoeuvres improved one's handling and control of the aircraft to the edge of its envelope through coordinated movement of controls and gave you a feel of what the aircraft could do in combat and how to take it through its paces without really having to look inside at the instruments.

I never forgot this technique and advice through my flying career, and even after retirement when I flew new and different types of small private aircraft. In my first few sorties on a new aircraft, I practised such manoeuvres combining it with smooth movement of the controls till I could handle the aircraft and put it through any desired manoeuvre, just by feel without really looking inside except a quick glance at a particular instrument only to check if I had achieved the desired value of that parameter. Even when I first flew the MiG-29 in the Soviet Union, I started such manoeuvres in my very first dual sortie with Captain Yuri Xoxlow, the instructor pilot, wondering what I was doing. Since I could not explain anything in the air in my broken Russian and he did not understand any English, I later explained to him after the sortie that I was just trying to get a good feel of the aircraft. This soon brought Major Kalsov, the senior pilot in that MiG-29 training squadron in Lugovaya, to me with a caution that I could do what I wanted over Rajpath in Delhi but in Lugovaya, I must follow only what was laid down by the syllabus. Later, even he relaxed the limits for me quite a bit with a nod from the Squadron Commander, Lt Col Nudeganov. I personally feel that this one nugget left with me by Babla Senapati formed the basis of what I slowly built on later with experience, amalgamation of what I picked up from other seniors and my own theories to perfect my combat flying and aerobatic displays. I also taught this refined technique to all my pupils and others whenever I got the opportunity by impressing on them that if they could also perfect such handling of the aircraft, they would be able spend most of their time looking outside the cockpit for bogeys, controlling their own formations in combat, navigating or doing the radio, everything a fighter pilot is required to do, being alone in the cockpit. While quantifying the time spent outside of the cockpit was difficult, I used to use an arbitrary figure of 98% of the time and attention with only 2% for looking inside particularly by day in VMC, as an example.

Unfortunately, I never got another opportunity to fly with Babla Senapati but was fortunate enough to bump into him in a restaurant in Bandra, Bombay those days, in May-June 1976 while doing the Photo Interpreters Course in Poona. Babla was obviously a bit down and out and waiting for the restaurant owner with some designs of a hotel/restaurant that the owner was supposedly planning in New York. I decided to pay my debt to him and invited him over to our table and stand him lunch while he waited for the owner, While I introduced him to Malini, my wife who was with me at that time, and thanked him for what he had taught me many years ago, a sortie which he didn't even recall, Babla Senapati showed us the design of the planned hotel/ restaurant based on the peacock. Those were truly amazing blueprints and designs and I then realised that Wing Commander "Babla" Senapati was not just a great flyer and instructor bur also a great artist and painter. Unfortunately, like most of such geniuses, he was a simpleton and did not care about his finances, did not know how to negotiate the right price for his talents/work and had fallen on hard times. We also took a photograph with him. Unfortunately, we packed our stuff when proceeding to Iraq in 1979 and by the time we opened the old stuff many years and many postings later, perhaps after retirement in 2006, white ants and some seepage through the years had taken their toll and we lost most of our papers and photographs of the early pre-Iraq years. I never met Babla Senapati again, never got to know whether he got a decent contract for the Peacock design for New York and later learned that he had passed away in penury.

Wherever he is today in the valhalla, I want him to know that I still fondly remember him and salute him as also VP Kala.



Air Vice Marshal (R) Cecil Parker and his.....

GURUS WITH WINGS

In this digital era greetings cards have migrated to the internet and e-greetings have become common place. There are however diehards from my generation (i.e, those born the same year as our air force or thereabouts) who continue to snail–mail personalised, hand written greetings on special occasions. Among the dwindling number of end-of-year greetings cards we received in 2021, was one from a 95-year old IAF officer settled in the UK. Good memories make good stories and I well remember first meeting Flt Lt Norman Walker (3405) GD (P) of No 41 Pilots Course circa 1946 when he was a flying instructor and I was a flight cadet at No. 1 Air Force Academy in Ambala in 1951.

My own instructor was that marvelous man Navroze Lalkaka who instilled the love of flying while teaching us its skills. In those days, to increase the variety of training inputs, it was an informal policy to programme pupils to occasionally fly with QFIs other than their own. My log book reminds me that I flew instructional sorties with Cecil Digby, Rampal, Les Preston, Babla Senapati, Norman Walker, Jaggu Shaw, Pete Wilson, Sham Powar and CGI Philip. This covered the 18 month training period of my Basic Stage (Tiger Moth) and Advanced Stage (Harvard) before earning my wings and being commissioned in August, 1952. In a few cases personal friendships developed between instructor and pupil that lasted a lifetime.

Like Navroze, Norman had a nice, easy, informal, friendly approach to teaching both in the air and on the ground. Flying per se, is one profession in which learning never stops till one leaves the cockpit for the last time. The years passed and, while attending the course at the RCDS in the UK in 1980, I was invited to attend the annual get-together of the IAF Association in the UK. My wife and I were happy to meet up with some old/senior friends settled in the UK including an ex-squadron commander, David Bouche, coursemate Buster Kaul and Norman Walker who immediately invited us to his home. He had left the air force in 1954, emigrated and created a very successful business in the UK. Despite not having re(visited) India in 60 years, Norman's Hindi is still surprisingly fluent and he is nostalgic about his house in Nagpur. As a young school boy there he recollected a gathering which included Mahatma Gandhi who patted his head in passing. After my own retirement from the air force in 1986 we travelled regularly to the UK to visit our daughter and family who had settled there. On nearly every occasion Norman would ensure mutual visits and

Representational image of the De Havilland DH-82 Tiger Moth (Photo: Angad Singh at Yelahanka 2015)

never failed to enquire about his friends and colleagues in the air force. A few years after he became a widower he remarried a widow who herself has now passed away leaving this nonagenarian guru with wings alone to look after a handicapped adult son. Yet, he still finds time and has the energy to send us a personalised, hand-written greeting card every year…..long may his tribe increase.

A JOURNEY

1932-52

This writer was born in 1932 to a mother from Gujarat and a father from Madhya Pradesh. My nomadic life-to-be commenced with childhood and education spread over Bengal, Bihar and Uttar Pradesh. My boyhood dream to 'fly' materialised when I was selected to join No 58 PC (Pilots Course) at No 1 AFA (Air Force Academy) in Ambala (Punjab/Haryana). Soon thereafter it was relocated to Begumpet, an airfield in Secunderabad, then in the erstwhile Nizams state of Hyderabad (subsequently Andhra Pradesh). It was here, as a flight cadet, I was destined to meet and court the young lady I was to marry five years later. On 30 August, 1952, at my POP (Passing Out Parade), she was introduced to my parents and received an invitation to visit our home then in Calcutta (Kolkata). As a newly commissioned young officer in the fighter stream, my air force journey commenced from Begumpet (Tiger Moth/Harvard) to nearby Hakimpet (Spitfire/Tempest).

1953-86

On 1 January, 1953 I reported to my first squadron in Palam (Vampires) and thereafter to Ambala (Toofanis) – Tambaram (HT-2/T6G) – Jodhpur (Prentice/HT-2/ Harvard). During this period the young lady graduated, became a teacher and our courtship was conducted by post! On 14 February, 1956 we were married in Secunderabad and my onward journey was now enriched by a wife, companion, helpmate and supporter who brought meaning and direction to my life. In the next 30 years of my life in the air force, she set up home 17 times, continued teaching whenever possible, designed our future home (built in 1976), performed her duties as local President of AFWWA (Air Force Wives Welfare Association) wherever required and brought up two wonderful children who added meaning to our lives.

From Jodhpur our joint journey continued on to Ambala (MEU) – Palam (Devon/Vampires) – Wellington (DSSC) – New Delhi (Air HQ) – Palam (Hunters) – Jamnagar (Hunters) – Hindan/Pathankot (Hunters) – Wellington (DS Air) – Bangalore (HQ TC) – Hakimpet (Iskra/Chetak/Kiran) – Adampur (Migs) – London (RCDS) – Wellington (CI Air) – Hyderabad (Kirans) and finally Udhampur (Heptrs/Jaguar). It has been a wonderful profession as I had thoroughly enjoyed my time in the cockpit but my days of active flying (3642 hours) were now coming to an end. In 1986 the air force opened up an option to take premature retirement. I was happy to do so and move on.

1986-(2022)

The next decade was spent in the corporate world in Mumbai followed by an equally constructive tenure in the academic world back in Hyderabad where we were happy to finally live in our own home in the AFOCHS Ltd Vayupuri. Retirement from all commercial activities now gave me control over my own time for favoured interests like tennis, swimming, reading, writing and travel by choice. Our journeys have taken us from USA in the west to Japan in the east and from Norway in the north down to South Africa. Our two children (now both in their early sixties) have made their own lives and augmented our family with six grandchildren, one great grandchild plus one more due in April. 14 February 2022 marks 66 years of the joint element of my journey which had commenced in the colonial era, spanned World War II, Independence, Partition, 35 years in the IAF from J & K to TN and from Gujarat, where it all started, to Telengana where it will terminate in due course.

Representational image of Jaguars (Photo: Simon Watson)

Representational image of an IAF Hunter

25 Years Back

From Vayu Aerospace Review Issue II/1997

First Su-30s Arrive In India

Even as some eighty personnel of the Indian Air Force remain at a number of air bases and establishments around Moscow for conversion training on the new generation Sukhoi Su-30 multi-role fighter, the first four aircraft for the IAF, disassembled and in crates, have been flown to Lohegaon by special Antonov An-124 aircraft, arriving at this air base near Pune in Western India during the second week of March 1997.

Prithvi Enters Service

The Army version of Prithvi SS-150 surface-to-surface missile was displayed at the recent Republic Day parade in New Delhi. Belonging to the 333 Rocket Regiment, some Prithvi's were earlier displayed during the passing out parade at the Air Force Academy near Hyderabad, with the announcement that the longer range version, the SS-250, was to be shortly inducted by the IAF after final trials at the Chandipur (Orissa) firing ranges in late February 1997.

HAL Highlights for 1996-97

The year 1996-97 has been a successful one for HAL, a PSU under the Department of Defence Production and Supplies. HAL achieved a turnover of Rs. 1725 crores against the previous figure of Rs. 1567 crores, a 10% growth, and has posted a profit of Rs.105 crores against the 1995-96 achievement of Rs. 86 crores, a healthy 22% growth.

There have been significant improvements in all the financial parameters indicating an overall excellent performance of the company. It is also significant that both the Joint Venture Companies of HAL (HAL-BAe, Software Company and Indo-Russian Aviation Limited) have posted profits. During the year, HAL has exported products and services to 15 countries (with Thailand being added to the list), the total export is Rs.33 crores.

No 50-Seater Airliners?

According to civil aviation sources, Indian Airlines may abandon its plans to purchase six 50-seater aircraft if the government does not give compensation for operating them on uneconomical routes. "If the government wants us to operate them (the 50-seaters) on uneconomical routes, then it must compensate for the loss of revenue. Otherwise, we may not go in for this purchase, Indian Airlines Managing Director has stated recently.

Operations of 50-seatet aircraft in far-flung routes will be totally uneconomical in the existing fare structure, said PC Sen, who is also the Joint Chairman of Indian Airlines and Air India.

New ATC Tower At Bombay: Safety Hazard Or Not?

The Civil Aviation Ministry has asked the Director General of Civil Aviation to enquire the "hazardous" Rs. 40 crore Air Traffic Control project at Mumbai and fix responsibility for it. This follows the report of the four-member Safety Committee headed by Air Marshal JK Seth which has recommended that the newly-built Mumbai ATC should be demolished as it is a safety hazard.

ACAS Mandatory

To ensure safety of air travel, the Government of India proposes to make installation of airborne collision avoidance systems (ACAS) on all aircraft mandatory from 31 December 1998. Civil Aviation Minister C.M. Ibrahim announced this in the Lok Sabha on 21 March and said that it was proposed to make carriage of the ACAS system mandatory on all airliners having a seating capacity of more than 30 passengers or payload capacity of more than three tonnes in case of cargo aircraft. No aircraft shall be allowed to be imported after 31 December 1997 without the installation of ACAS system.

NAL Saras To Have Indian Partners

Having awaited some positive moves from its erstwhile Russian partner MDB, National Aerospace Laboratories (NAL) have finally "written off" Russia as a partner in its 14-seater aircraft project. Instead, it has tied up with two Bangalore-based companies, Taneja Aerospace and Kumaran Industries, to build the prototype of its 'Saras' aircraft.

The An-32 "Mystery"

Even eleven years after its mysterious disappearance, there are no clear indications as to why an IAF Antonov An-32 being ferried from Kiev to India simply "vanished". That the unsolved mystery has not been completely forgotten was established in Parliament on 3 March through an unstarred question in the Lok Sabha from Mr. Ramashray Prasad Singh (CPI). The Minister of State for Defence, Mr. NVN Somu, confirmed the incident but could not offer much by way of explanation.

Varyag To Be Scrapped In India?

An absolutely new Russian nuclear-powered carrier being built at an Ukrainian shipyard will be sent to India for scrapping as the former military super power is unable to pay for its construction, according to reports from Washington. The carrier 'Varyag' will be sent to India through a European company that has bought it, the sources stated, quoting a top secret CIA report.

UAE Considers More Mirage 2000s

Air Force of the United Arab Emirates is considering purchasing an additional batch of Dassault Mirage 2000E fighter aircraft, as well as carrying out a major upgrade on the aircraft it already has in service. The service is looking at purchasing upto 18 further Mirage 2000s including two-seat trainers. The UAE Air Force are also looking at a Dassault proposal to upgrade the Mirage fleet, used in the quick-reaction-alert fighter role, with the Thomson-CSF RDY radar, as well as considering improved cockpit avionics and weapons suites.

Tale Spin

An 'Oooops' moment

In an embarrassing (and unacceptable) moment for India, a Brahmos missile was accidentally launched from Sirsa and landed about 124 kms inside Pakistan. In a rare acknowledgement from India's MoD and a calm but measured response from the Pakistan side, one can only hope that a new sense of maturity is beginning to develop between the two neighbours.

Ministry of Defence

Azadi Ka Amrit Mahotsav

Statement on accidental firing of missile

Posted On: 11 MAR 2022 6:33PM by PIB Delhi

On 9 March 2022, in the course of a routine maintenance, a technical malfunction led to the accidental firing of a missile.

The Government of India has taken a serious view and ordered a high-level Court of Enquiry.

It is learnt that the missile landed in an area of Pakistan. While the incident is deeply regrettable, it is also a matter of relief that there has been no loss of life due to the accident.

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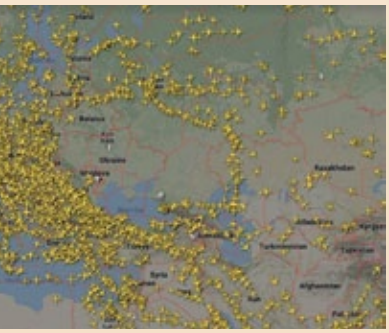


Congestion in times of crisis

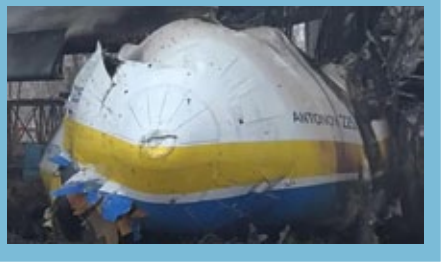
A grab from Flightradar24 on 12 March 2022. Ukrainian airspace closed entry of civil flights as of 24 February 2022. Russia issued its own NOTAM closing its western airspace bordering the Ukrainian border. Worldwide disruptions and readjustment in progress.

Desert rose?

No, not an image from the Thar Desert in India. On 24 February 2022, NASA's Mars Curiosity Rover captured this image of a flower-like rock on Martian soil. Smaller than a penny, this and a bouquet of other findings gives scientists an insight into the Red Planet's ancient past. (Courtesy: NASA)

A legend is gone

The world's largest aircraft An-225 falls victim to the Ukranian/Russian conflict. What is was. What is left. This gigantic beauty has now left the aviation community. (Images via Youtube)



Afterburner

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