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THE EVOLUTION OF AIR DEFENCE AND THE WAY AHEAD

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INTRODUCTION

Air defence or 'fighter control' has its origin in World War II and specifically 'The Battle of Britain'. Defence against aerial attacks became a critical element of war-fighting since aircraft started impacting the outcome of war. Strategic targeting of the entire range of the enemy's national assets was being undertaken and, ultimately, the fight reached the doorstep of each city. Hitler had chosen the bombing of London and other British cities as his final instrument to make the Allies surrender and he almost succeeded till the Allies found a system to blunt the German attacks. The advent of radar and its effective use by Britain changed the outcome of the war. The quote by Master of the Royal Air Force (MRAF) Sir William Sholto Douglas, describes the importance and priority given to the air defence for the success of the Battle of Britain:[1] "I think we can say that the Battle of Britain might never have been won … if it were not for the radar chain."

HISTORICAL BACKGROUND

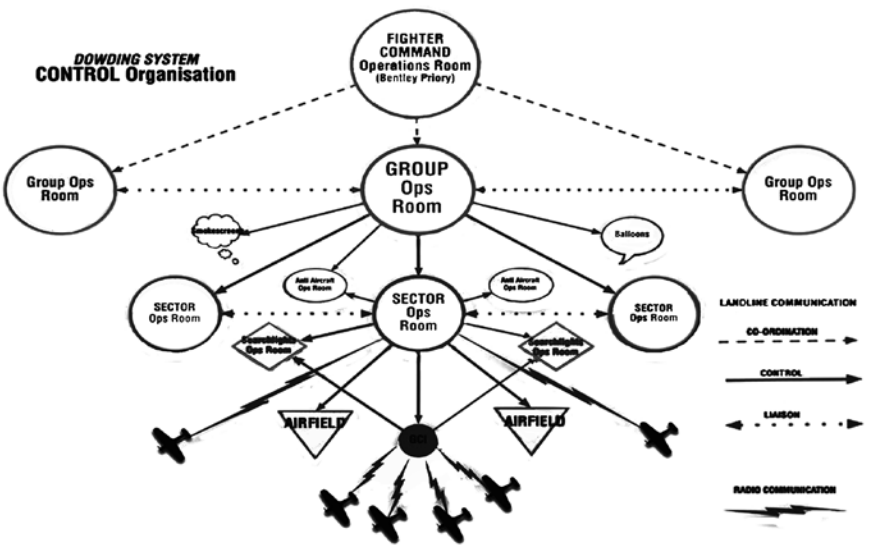
The organisation of various elements of air power to weave an effective air defence as we see today, can be credited to Air Chief Marshal (ACM) Dowding

Air Marshal **VPS Rana,** PVSM, VSM (Retd) is a Cat AYE Master Fighter Controller and former Air Officer-in-Charge Administration (AOA) of the Indian Air Force.

1. "An Article on History of Battle of Britain Highlighting the Role of Radar", www.rafmuseum.org.uk/reserach/online-exhibitions/history-of-the-battle-of-britain/radar-the-battle-winner. Accessed on December 4, 2022.

who was the commander-in-chief of the Fighter Command. He devised an organisation and system of integrating various elements of air defence which was called the "Dowding System: Control Organisation". He conceptualised a well-knit control organisation, integrating the weapons, radars, observers, balloons and airfields. He is regarded as the architect of the victory in the Battle of Britain. He devised a chain of operations rooms at the Fighter Command, group and sector levels in a hierarchical manner. The Operations (Ops) Room of the Fighter Command at 'Bentley Priory' was the highest organisation where all strategic inputs were gathered and filtered information was passed down to three Group Headquarter Ops Rooms (Groups 10, 11 and 12) which, in turn, would pass on the requisite information to various Sector Ops Rooms from where the fighter control and control of other weapons would be exercised. This was akin to command and control being exercised by most Air Forces today. In our context, the Air Defence Operations Rooms (ADORs) are akin to Group Ops Rooms and Sector Ops Rooms are akin to the Air Defence Direction Centre (ADDC)/Air Command and Control System (IACCS) nodes.

Fig 1: Dowding System Integrating all Fighting Elements of Air War



Source: https://www.rafmuseum.org.uk/research/online-exhibitions/history-of-the-battle-of-britain/how-radar-works/

The system worked on a series of Chain Home (CH) radars all along the coastline of Britain to pick up the enemy raids, and pass these to relevant groups and sectors to launch their own fighters in time, give information to anti-aircraft artillery, and also balloons to neutralise the raids. Despite its success, the CH system did have drawbacks. Unlike modern radars, CH aerials did not rotate. A broad beam of radio pulses was transmitted, 'floodlighting' a vast area with detection ranges up to 320 km (200 miles approximately).[2]

ACM Dowding, unlike Hermann Göering, his German counterpart, recognised the importance of radar and its integration into an overall air strategy. Initially, the German bombers targeted radars and sector stations, but by August 1940, Göering, believing these attacks were ineffective, decided to concentrate on the bombing of British cities. Göering's inability to grasp the vital role radars played in British air defence enabled the Royal Air Force (RAF) to retain the advantage in the air. Had Göering continued the attacks on the radars, the outcome could have been different.

Fig 2: Ops Room No 10 Group Headquarters: Plotters Plotting the Aircraft

Source: https://www.youtube.com/watch?v=7ktspgoffnU&t=5s

2. A video titled, "How a Map won the Battle of Britain", dated April 5, 2009, on the Dowding system at www.youtube.com/watch?v=1yXxc4ApxmQ. Accessed on December 4, 2022.

The arrangement of various operations rooms and control of fighters from control stations known as fighter control gave birth to the skill called 'fighter controlling', wherein the ground controllers would scramble fighters in time, based on the filtered inputs from the radars and then provide the processed input to the airborne fighters to enable them to pick up and destroy the enemy aircraft. In a well-defined manner, the position of all the aircraft would be plotted on a large-sized table and an air picture presented for analysis and tactical actions.

EVOLUTION OF AIR DEFENCE IN THE INDIAN CONTEXT

India was involved in World War II through the Royal Indian Air Force (RIAF) and many of our veterans in various capacities fought the war on all the fronts. Air Force historian Anchit Gupta, with the help of Group Captain ML Bountra, a highly revered veteran fighter controller, has brought out a great account of the origin of the Air Defence (AD) set-up in India, through a series of tweets. Excerpts from his well-researched tweets on the subject, reproduced below bring out the early history of air defence very lucidly,

> Prior to 1942, even the word 'radar' was treated as a secret and Indians were not allowed to get close. When the war in the East started to gain importance, the first batch of Indian radar officers was commissioned and sent to the UK for training. By 1945, as the war ended, the British government in India decided to do away with radars. Radar was considered too advanced for the IAF and radar for India deemed unnecessary. All equipment was, thus, left severely damaged and sabotaged. Most of the radar operators and mechanics were permitted to leave or change their trade/branches. Immediately after Independence, the Indian government decided to recall all the released officers and airmen to revitalise the nucleus of radar capability in the IAF. In fact, the IAF had a 'Radar Branch' for officers.
>
> A mobile 'Type 22 Station, including one 'Type 11 search radar' (500 m/c band) and one 'Type 13 Radar' (10 cm band) was the first to be made operational. This unit was christened 'No 1 Radar Unit' and moved

to Palam (1948), becoming the first SU in the IAF. A few officers from the Flying Branch were trained as fighter controllers in the UK in 1952. Later, the C&R School was established at 18 SU, Jodhpur. The course started here in January 1958. Induction of Administration & Special Duties (Adm) branch controllers commenced from November 1958.

The first ten flying branch officers to be trained as Fighter Controllers included GK John, Randhir Singh, NL Soundarrajan, JR Bankapur, RL Sayee, KD Irani, KT Abraham, M Dhanraj, CV Gole and Sheorey. Out of these, John, Randhir Singh and CV Gole rose to the rank of Air Marshal. KT Abraham received a Vayu Sena Medal for his role as Commanding Officer of a SU during the 1971 war.

The radars in 1962 consisted of one Type 8 radar, six T-13 radars, seven T-14 & T-15 radars. Control capability of these radars was degraded due to high clutter and unreliable height information.

Table 1

Unit	Unit Type	Eqpt	Region
11 SU	SOC	T-13/14/15	Delhi
16 SU	SOC	T-13/14/15	Ambala
18 SU	SOC	T-13/14/15	Jodhpur
20 SU	SOC	T-13/14/15	Barrackpore
27 SU	SOC	T-13/14/15	Bombay
12 SU	GCI	T-8/15	Mobile
35 SU	GCI	T-15	Mobile
55 SU	GCI	T-35	Mobile
149 SU	GCI	T-15	Mobile
36 SU	EW	AN/TPS-1E	Mobile
43 SU	EW	AN/TPS-1E	Mobile
91 SU	EW	AN/TPS-1E	Mobile
121 SU	EW	AN/TPS-1E	Mobile

Source: Authors collated data.

Deployment of radars gave the main cities of Delhi, Calcutta and Bombay AD cover and two Sector Operations Centres (SOCs) in Ambala and Jodhpur covered the ingress of the enemy from the west.

As can be seen, the deployment of radars gave the main cities of Delhi, Calcutta and Bombay AD cover and two Sector Operations Centres (SOCs) in Ambala and Jodhpur covered the ingress of the enemy from the west. The radars which were mobile could be deployed to augment the SOC functioning in any sector. These were the radars that were used to guide the fighter aircraft from the ground control station at the Sector Operations Centre/Ground Control Interception (SOC/GCI). Early Warning (EW) radars were to provide EW of the enemy.

The battle management part of Air Defence (AD) has been referred to as Control and Reporting (C&R) from the early days of the IAF. Group Captain Bountra has also catalogued the history of C&R from its early days. His inputs on the initial AD set-up and establishment of the C&R School and its move to its present location, are must-read to understand the historical perspective. His narration of this journey is given below:

> The C&R School was established at Jodhpur in 1958 to train Fighter Controllers in various aspects of AD operations. The school was co-located with 18 Signal Unit (SU). It was a specialised course of 12 weeks duration. The school was moved to its current location immediately after the 1971 war.[3]
>
> Planning for induction of radars started some time at the beginning of 1950. The air defence concept was envisaged on the British pattern of SOCs, GCI and EW units. The first SOC, 11 SU was established in Delhi in 1954. From the mid-1950s to the Indo-China War in 1962, the ground

3. Excerpts of interview with Group Captain ML Bountra and Vikram Singh, "Squaring off: The Balance of Forces and its Implications", in Air Marshal Anil Chopra and Dr Shalini Chawla, eds., *The 1971 INDO-PAK Air War: Reflections and Projections* (New Delhi: KW Publishers, 2021), pp. 33-34.

radar environment of the IAF consisted of five SOCs; 11,16,18,20 and 27 SUs, each equipped with Marconi T-13 (Ht finder), T-14 and T-15 radars, four mobile units; 12, 35, 55, 149 SUs with T-15 (149 SU had additional T-8 radar also) and four EW; 36, 43, 91,121 SUs with ANTPS1E radars. There were no video maps or cursor facilities in any of the radars. The T-15 radar operated on three RPM and had a maximum range of 150 NMs. International borders and airfields/important locations were marked on a talc sheet and superimposed on the console. Pick-up used to be very intermittent and considered good if there were two/three blips in 6-8 revolutions. Due to the broad beam width of the main T-15 radar, the blip size was nearly 8-10 NMs large. The fighter force consisted mainly of Vampire aircraft (approx 30-35 per cent) with two-night fighter sqns and the rest comprising Toofani, Mystere, Hunter and Gnat sqns. The communication network was dependent on Post & Telegraph (P&T) landlines with W/T and HF R/T as standby. The IAF did not have an independent communication system of its own.

The Ops complex at the SOC Ops Room had a semi-circular sunk-in floor area where a big grey table marked with GEOREFF called GSM was used for plotting and a huge vertical Tote Board with wooden slats was utilised for display of information. There were cabins at a height of nearly 10 ft. overlooking the complete floor area, from where the Senior Operations Officer, Chief Controller, Fighter Marshal and Movement & Liaison Officer operated. The two interception cabins called Red & Blue in the main corridor had the radar consoles and VHF RT facilities from where observation and reporting were done by Rad/Oprs and Intercept Controllers carried out surveillance/ interceptions. Plotting was done by Plotters on the GSM table with painted metallic arrows using magnetic rods. Information on the Tote Board was displayed with colour-painted iron strips marked in capital letters and hung on the wooden slats. The whole floor area gave a very bright and colourful look.

The Fighter Marshal cabin had a round table marked with GEOREFF and three remote AD 200 consoles. The main equipment and aerials of the

> three AD 200s were deployed about 50-60 km away at different locations from the unit. These locations were marked along with a compass rose on the Fighter Marshal table and a hole was drilled at each of these positions through which a weighted string tied to a wooden rod was hung. Any time an aircraft transmitted to check its position, the readings from the three AD 200 consoles were plotted by pulling the string with a rod on the indicated bearing to get a triangulated fix and the ground position was informed to the pilot. Class 'A' fix denoted accuracy up to 5 NMs, Class 'B' 10 NMs and Class 'C' 20 NMs.

It can be well gauged how primitive our set-up was back then. The present generation of Fighter Controllers (FCs) who have operated in swanky Ops Rooms of the IACCS all along, would never be able to appreciate the hot and humid cabins equipped with primitive aids for undertaking missions which were equally critical back then. So much depended on the individual judgment of the FCs. After the Chinese debacle of 1962, the AD set-up underwent a speedy overhaul and many new advanced radars as well as fighter aircraft were procured. Group Captain Bountra (Retd), recalls fondly the period when he was posted to two of the best SUs of that era, which were proudly referred to as 'Mecca' and 'Medina' of the AD C&R set-up. His account of that period is as vivid as it could be and is summarised below,[4]

> Full-scale modernisation of the IAF started immediately after the Chinese debacle of 1962. Orders for twelve MiG Sqns were placed with Russia (each Sqn had one associated P-30 radar) and the US was also requested to provide ground radars and training. Six American Star Sapphire units (500 series) with FPS 89 & FPS 100 radars and twelve P-30 units (200 series) were sanctioned for induction over the next five years. Locations of Star Sapphire units were planned primarily to counter the

4. Ibid.

threat from China. Because of the US influence, complete works services for technical, admin and domestic accommodation were carried out simultaneously at each location to make the Star Sapphire units self-sufficient in all respects. It was also decided to have an independent tropo communication network to reduce dependence on P&T lines. A new Radar & Communication Project Office and Dte of Plan ADGES were created at Air HQ to undertake the task and oversee the installation and commissioning of radars and tropo communication network. Two ADCCs, one each at Western Air Command and Eastern Air Command were also established.

A joint exercise 'Shiksha' with the US and UK was conducted in the Western and Eastern sectors in November 1963. For this purpose, two units (311 and 411 SUs), each with US MPS 11 and 16 radars were also deployed at Patiala and Rampurhat respectively. The exercise was a big learning experience and Indian controllers proved their worth and impressed the visiting foreigners with their skills and interception capability. The US radars provided good coverage during the 1965 Indo-Pak War. Pilots, Technical staff and Controllers were sent to the US and Russia for familiarisation and training on the proposed acquisitions. The induction of new radars and MiG aircraft commenced from mid-1964 onwards. Categorisation and qualification pay for controllers were also initiated. It took another one to two years for the new sqns and radar units to be operational.

From British terminology, we switched over to the American designations. Instead of Controllers, we were now Directors. SOC was renamed as ADDC, Chief Controller and Intercept Controller were designated as SD and IND, MLO switched over to M&IO, Floor Supervisor was now called ASO, and trades of Rad/Opr and Ftr/Pltr were merged and renamed as ADSO. Plotting and display of information were done on big Perspex Vertical Plotting Boards. Ops Rooms instead of being bright and colourful, were now dimly lit.

Fig 3: Plotting Being Done by Chinagraph Pencils on Vertical Plotting Boards

Source: https://f4t-hph.github.io/management/3.-classical-tools/

This narration explains how the initial radar units were established and located in remote far-flung places with little interference and dominating heights to get better radar coverage. With P-30 M radars, the concept of mobility of radars was introduced. Later, P-40 radars were also acquired, along with the MiG-29 aircraft which boosted our capabilities further. These radars were later replaced by the French radar TRS 2215 and the indigenised version, PSM 33. Some time in the mid-1980s, the American radars (FPS series) were replaced by the high-powered THD-1955, which continue to operate even today with time-to-time modifications incorporated indigenously.

EVOLVING AIR DEFENCE CONCEPTS OVER THE YEARS

The ADDC concept evolved with the proliferation of radars and other resources post-1962 Indo-China War, when the 500 series radars were received from the US, and MiG-21 and P-30 M radars were received from Russia. The SOCs were renamed as ADDCs and 500 series radar were established

in the western sector (Barnala and Delhi), central sector (Singarasi and Memaura) and eastern sector (Shillong and Dinjan). Each of the ADDCs had its GCI radars, mainly the P-30 class and a few EW radars. The ADDCs controlled the weapon systems comprising fighter aircraft, Surface-to-Air Missiles (SAMs) (SA-2 initially and later SA-3 and SA-8) and AD guns.

In this concept, the entire responsibility of conducting air defence operations hinged on the ADDCs. The executives in the Ops Room included the Sector Director (SD) who was responsible for all operations within the defined sector, assisted by the Control Executive (CE) who was responsible for the control of weapon systems assisted by the Interceptor Director (IND) to control the fighter aircraft and Recovery Director (RD) to recover the aircraft to the respective bases. The control orders for missiles and guns would be passed through the respective liaison teams in the Ops Room. The important task of identification, was allotted to the Movement and Identification Officer (M&IO). All these executives were trained Fighter Controllers (FCs) under the Chief Operations Officer (COO), responsible for overall operations and training of all operational crew. In the late 1970s and early 1980s, many officers of the Flying Branch also were trained and posted as FCs. The station commander of the ADDCs would also undertake the role of sector commander during operations but the operations in general were primarily controlled by the COO with the help of professional FCs. The entire concept revolved around area defence.

With a majority of Pakistan Air Force (PAF) attacks directed on airfields in the 1971 War, a need was felt to have dedicated air defence for our air bases. This resulted in the evolution of the Base Air Defence Centre (BADC) concept with a certain degree of independence for air defence within the defined Base Air Defence Zone (BADZ) (ranging from 25 to 40 km).

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(BADC) concept with a certain degree of independence for air defence within the defined Base Air Defence Zone (BADZ) (ranging from 25 to 40 km). The BADC was a point defence concept primarily for the protection of airfields, while ADDCs continued the control of areas outside the BADZ. Under the concept, each base would establish a BADC where the Base Air Defence Officer (BADO), assisted by the Base Air Identification Officer/Base Fighter Controller/ Base Missile Controller and Combat Air Patrol (BAIO/BFC/BMC and CAP) controller, would take on the enemy aircraft once the raid was handed over to them either by the ADDC or a surprise raid was picked up by the BADC itself. The acquisition radars of missile squadrons like the P-12/P-15s (later P-18s/P-19s), were the main sensors for the BADC in addition to the base Surveillance Radar Equipment (SRE) for the purpose of interceptions. The system relying on manual inputs had its inherent limitations in terms of reaction time. The Mobile Observation Posts (MOPs) deployed in a double or triple-layered fashion, ahead of the base to give a visual warning of enemy raids, were very important elements of this concept.

Some time in the late 1980s and early 1990s, with the arrival of good low-level radars like the ST-68 and Indra series, the Control and Reporting Centre (CRC) concept emerged, wherein the cluster of low-level radars was established, with a CRC HQ initiating tactical actions and control of interceptors (fighters) being undertaken from the radar cabins of these radars referred to as Limited Ground Control Interception (LGCI). The concept proved successful against low-level ingress from the enemy. However, due to the limited numbers of the radars, the CRCs were set up close to the border and at the likely ingress route of the enemy, thus, covering only a limited area. The concept was also referred to as Limited Air Defence Control (LADC). The CRCs were in conjunction with the BADC and ADDCs. This also was a manual system and had its own limitations. The mobility of the radars to appropriate field locations was the new challenge to these mobile radar units in view of the poor road connectivity and non-availability of adequate space to set up the units.

Many attempts were made to automate the process of C&R to ensure a prompt and timely response to enemy threats. The journey of automation saw the Automatic Data Handling System (ADHS) and Semi-Automatic Data Handling System (SADHS) with the induction of the French THD-1955 radars, which had replaced the US FPS-100 and FPS-89 radars in the early 1980s. While this was a big jump in data processing, presentation of processed data and radar simulators to train the fighter controllers, the automation was still confined within the single Ops Room of the radar, with no provision of fusing radar data from various sensors and presenting a combined picture.

The Low level Radar Networking Group (LRNG) was set up in the late 1980s to automate and present fused data from a number of sensors at Ambala. It was also referred to as the Auto CRC.

The Low level Radar Networking Group **(**LRNG) was set up in the late 1980s to automate and present fused data from a number of sensors at Ambala. It was also referred to as the Auto CRC. After many years of trials, the first unit was established as 601 SU with the ST-68 and Indra II radars as its sensors. The system was capable of undertaking interceptions from the CRC shelters, far away from the cluster of radars, with the help of data transfer from radars to the CRC through satellite communication. Despite it being a technical marvel, the concept had a few limitations and was not followed beyond setting up of one automated CRC.

In the late 1990s, the IAF, looking for a fully automated system, started evaluating various systems across the world and, finally, decided to develop one indigenously. After many years of academic and technical deliberations, with many FCs and technical officers of repute combining their expertise for the development of the system, it took shape after about a decade in the form of the IACCS. I was fortunate to find myself in the midst of the development and operationalisation of the system from 2008 to 2010 as Director of Operations (IACCS). Despite starting on a clean slate, with no prior references and developments in the field in India, the team of IAF officers and software engineers

of Bharat Electronics Limited (BEL) and many other smaller companies, a world-class system was developed which today is the backbone of all operations. Each day of development and operationalisation had its own interesting history of obstructions, academic brilliance, long hours of deliberations, disappointments, endless discussions with BEL, capturing exact system requirements that were changing frequently, and tremendous team effort.

In the network-centric warfare era, the Recognised Air Situation Picture (RASP) plays a very critical role and is required to be made available at the appropriate level for executing a series of tactical decisions. The IACCS receives data from different types of radars and integrates other data elements from various other military or civilian agencies to create a real-time comprehensive RASP at the IACCS node. The data is presented to various levels i.e. strategic level (Air Headquarters), operational level (Command Headquarters) and tactical level (divisional/sector level) after due processing. The connectivity of sensors/agencies from/to the IACCS is deployed on a wide area network based on the Internet Protocol (IP).[5]

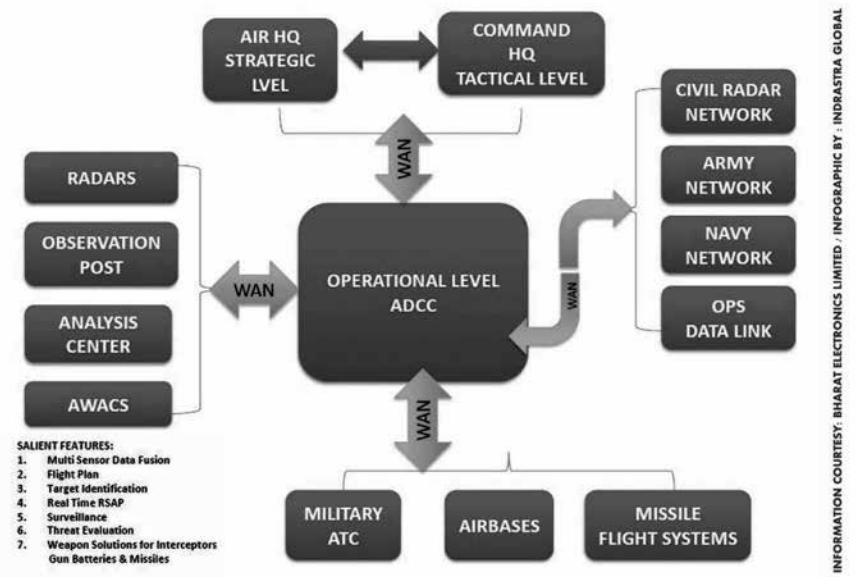
Fig 4: Operations Room of an IACCS Node

Source: https://defenceforumindia.com/threads/iaf-mig-21-shoots-down-pakistani-f-16.81461/page-50

5. "An Analysis of IACCS", at www.indrastra.com/2015/09/ANALYSIS-IACCS-257.html. Accessed on December 4, 2022.

The importance of the IACCS can be gauged by the IAF statement during the visit of the defence minister to one of the IACCS nodes in August 2022, "The system (IACCS) is the backbone of the IAF's march towards network-centricity and is a key enabler in operations. The system's capabilities endow its users with an enhanced situational awareness that reduces the IAF's sensor-to-shooter loop. The robust system has redundancies built into its functioning which enable seamless operations between its assets across the country." During his visit, the defence minister was shown a demonstration of various networked operations conducted at varied locations across the country, including synergised operations of fighter, transport and Remotely Piloted Aircraft (RPA).

Fig 5. Integrated Air Command and Control System



Source: https://www.indrastra.com/2015/09/ANALYSIS-IACCS-257.html

The induction of the Airborne Warning and Control System (AWACS) was a big boost to the IAF, particularly with the ability to provide low-level coverage. With its ability to take on independent command and control units,

as well as its integration with the IACCS as the potent sensor, it became a much-required force multiplier in the air defence domain. It also provided the opportunity for the FCs to operate from the air and get a different perspective on air operations. With this induction, the IAF came at par with the best Air Forces in the world.

Along with all these developments, the C&R has also seen tremendous modernisation of Air Force Movement Liaison Units (AFMLUs) at major civil airports for effective coordination with civil aviation, including the real-time data flow from civil radars and systems. The establishment of the Joint Control and Analyses Centre (JCAC) and Operations Direction Centre (ODC) alongside the AFMLUs at civil airports has added to the efficacy of air defence to deal with rogue elements of the 9/11 kind of threat.

EVOLUTION OF FIGHTER CONTROLLING AS A SCIENTIFIC ART

'Fighter controlling' is a skill with a scientific backdrop, just like flying. There are specifics of orientation theory, mathematical modelling of interceptions, radar theory, the impact of weather, individual aircraft capabilities, etc., which have a direct impact on interception. These are proven sciences and need to be mastered by the FCs. But many things that need to be applied to a given situation are intangibles like enemy intelligence, ability to prioritise the communication in a clear and concise manner, confidence in voice, ability to comprehend the situation from the communication with the pilot, appreciation of the enemy's likely tactics and, above all, instincts. This is the art part of the profession.

Fighter controlling has evolved in the IAF over the years. In the earlier days, it comprised more pure skill, as the inputs available to the FCs were few and far between, and they had to deal with poor data like large blip size (each blip would cover 10-20 km on scope), a frequent drop of radar pick-up and radio communication. To extract the requisite information from this kind of data was a tough task. Today, the data presented is continuous, processed and precise, with many assisting tools available to the FCs. This is not to say that controlling has become easier. There are

now many other variables that the FCs have to deal with in a complex tactical scenario, with far more capable aircraft, in large numbers. However, the correct, continuous and precise data available to them helps in handling the tactical situation better.

The Tactics and Air Combat Development Establishment (TACDE) has had a great role in enhancing the quality of fighter controlling in the IAF. The involvement of FCs in a complete combat and tactical scenario is not to this extent in other Air Forces across the world. The role of FCs in other Air Forces is generally restricted to present the air situation to the pilot as seen by them. In the case of the IAF, the FCs are virtually part of the combat, and guide the pilot even for specific tactics and manoeuvres. They work like a team. The concept of pilot-FC team got enriched after the introduction of the Master Fighter Controller (MFC) course at the TACDE in the late 1980s. Gruelling training during this course and detailed analysis of each situation, from the FC's as well as pilot's perspective, entrenched this concept of the 'team' in the IAF. Mutual respect for each other's profession also grew manifold. Referring to each other on a nickname basis did wonders for their mutual confidence in each other. Recognising the voice of the person on the other side of the radio became a habit and gave a tactical advantage during intended or inadvertent interference in radio communication.

While the responsibility of AD is assigned to the IAF as per the Union War Book, the roles of the Army and Navy in their respective areas of operations are equally critical, particularly in view of the large air defence weapons operated by them.

JOINT SERVICES CONCEPTS AND AIR SPACE MANAGEMENT ISSUES IN TBA

While the responsibility of AD is assigned to the IAF as per the Union War Book, the roles of the Army and Navy in their respective areas of operations are equally critical, particularly in view of the large air defence weapons operated by them. A common protocol is essential to safeguard own aircraft

and, at the same time, ensure optimum utilisation of the air defence weapons of all three Services in order to neutralise the enemy threat. Many JSSGs in the past have attempted to propose joint Services procedures to deal with this sensitive issue. Having been part of two such JSSGs, I can vouch that it is not easy to sort out differences that crop up among different users. The conflicting demands for freedom of usage of air space by aircraft and air defence weapons in the same air space, make it a difficult task to grant the requisite freedom to all the users.

In an integrated environment, the IACCS nodes have a much clearer picture, yet the complications of real-time connectivity with all the elements in the Tactical Battle Area (TBA), mandate a certain degree of procedural control. This, however, is easier said than done and needs a tremendous amount of coordination among the Services. Joint training of Army and Navy counterparts, along with the FCs at the Air Defence College makes it a little easier to coordinate during exercises and operations. This, however, is a concept that needs frequent revisits and constant dialogues among the Services.

WAR AND COMBAT OPERATIONS FROM FIGHTER CONTROLLERS' PERSPECTIVE

There is not much documented history of the participation and contribution of FCs in war and other combat operations. Most of the mention is in passing, and generic, rather than a specific contribution, barring a few experiences in a few recent books, including the one published by the Centre for Air Power Studies (CAPS) on the 1971 War. Even the official history of the 1971 War by the Ministry of Defence (MoD), gives a generic account of the war, with very little mention of the contribution by the SUs. The background work by the SUs, however, was significant, as is evident by a few personal accounts of the veterans who participated in the war. Also, there are many incidents of significance like the Exercise Live Wire, Balakot strike, Purulia arms drop, Operation Parakram, Operation Vijay,

Atlantique shooting, etc. where the SUs in general and FCs, in particular, played a very crucial role. The official MoD report released on the 1971 War summarises the performance of C&R as follows:

There are many incidents of significance like the Exercise Live Wire, Balakot strike, Purulia arms drop, Operation Parakram, Operation Vijay, Atlantique shooting, etc. where the SUs in general and FCs, in particular, played a very crucial role.

> The tactical and technological innovations introduced by the IAF, particularly in perfecting a sophisticated radar environment, not only paid handsome dividends, but left defence analysts bewildered. By and large, the C&R performed satisfactorily within their design limitations. The ideal weather conditions of winter did enhance their performance.[6]

The MoD document refers to an interesting analysis of the failure of the PAF as follows:

> Analysing the reasons for the failure of the PAF, H.P Willimott writes (*War in Peace: An Analysis of Warfare Since 1945*): "The IAF was assisted by Soviet Moss aircraft. These were AWACS aircraft and this war seems to have been the first conventional war when such aircraft were used to fulfil their detection, control and communication functions. Every move that the PAF made was immediately known to the IAF and AWACS aircraft in conjunction with active Electronic Counter Measures, which threw a blanket over Pakistan in radar and communications. The IAF was able to operate between 320 to 480 km with impunity".[7]

6. Reference No 43 of Chapter 10: "IAF in the West of 'Official History of the 1971 India Pakistan War", reproduced at www.bharat-rakshak.com/ARMY/history/1971war/280-war-history-1971.html. Accessed on December 4, 2022.
7. Ibid.

The MoD document clarifies further,

> ... this analysis was totally incorrect, as no Russian aircraft operated from Indian soil or over the Indian skies. It is, in fact, a single tribute and acknowledgement of the skill and effectiveness of the IAF men and material.

There cannot be better proof of, and tribute to, the exemplary role performed by the FCs, technical manpower and the operation crew in various radars and command and control centres that were so effectively manned and managed on a 24 x 7 basis and that put such fear in the minds of the PAF pilots that they assumed they were being watched right from the time they were airborne and intercepted all along their flight path.

An article written by Wing Commander Avinash Chikte (Retd) in a book titled *The 1971 War: The Eastern Saga* based on the narration of one of the members of the four aircraft formations of Gnats over Boyra, Squadron Leader M A Ganapathy, that shot down three PAF Sabres, brings out the story as it unfolded that day. The excerpt given here brings out the role played by the pilots and the FC as a team,

> It was November 22, 1971. We had been on a detachment at Dumdum airport in Calcutta for months now. I came on ORP duty at 1300 Hr, with Flight Lieutenant Roy Andrew Massey, Flying Officer Donald 'Don' Lazarus, and Flying Officer SF 'Su' Soares. The morning shift pilots, which included our CO, had scrambled twice to intercept some PAF fighters over Boyra, but without luck. Flying Officer KB Bagchi, the FC, tested the communication and then came on the dedicated landline. I told him he could put us on 'Stand By Two' if he wants. I knew there seemed little hope that afternoon, since there had already been two 'fighter sweeps' by the PAF, but we were willing to fry in the sun to get some action (on S/By 2 pilots have to be strapped and ready in the cockpit).
>
> 'SCRAMBLE, SCRAMBLE, SCRAMBLE', suddenly the voice of Bagchi echoed on the PA system with further instructions following, 'COCKTAIL FORMATION, HEADING ZERO THREE ZERO, CLIMB TO ONE

THOUSAND FEET AND MAINTAIN MAX SPEED'. We scrambled and headed to Boyra. All of us knew the area well as we had memorized the terrain. 'INTRUDERS 2'O CLOCK 4 MILES', Bagchi announced.

Don and I being on the right side of the four aircraft formation, were closer to the enemy, but young 'Su', famous for his spotting, called out, 'CONTACT'. He then started a commentary on the enemy aircraft.

'WHAT TYPE?' Bagchi asked.

'SABRE', Roy replied. Su announced 'ANOTHER SABRE 7 O CLOCK'.

'CONTACT', I said and turned to line up my gunsight on the second Sabre. I fired, and on seeing fire erupt from the Sabre's wing, announced the code word for a confirmed kill, 'MURDER, MURDER'.

Suddenly, a third Sabre popped up from the haze below, barely 15 metres in front of Don, who got a quick shot at him despite the surprise. Meanwhile, Roy stayed in the chase and shot at the first Sabre that was diving and speeding away eastwards to Dhaka. The whole action lasted less than three minutes. Two Sabres crashed right there. The pilots ejected and were taken Prisoner of War. The third shot by Roy was damaged but got away. That was a great first battle even before the war was declared.

Flying Officer Bagchi was awarded a Vayu Sena Medal and three of us Roy, Don and I got the Vir Chakra and the Commanding Officer got a Vishisht Sewa Medal. Su did not have any aircraft left to shoot but he was our hero who spotted the enemy first and set the ball rolling. That day four Sabres had got airborne from Dhaka for Boyra, but one had a radio problem and returned to base. He could have been Su's victim. Or may be that fourth Sabre could have shot me down. Who knows?[8]

During wars, the swift mobility of radars at field locations, at times involving large distances was the key to the success of many operations in the eastern as well as western theatres. Many new installations also took

8. Excerpts of interview with Squadron Leaders Ganapathy and Avinash Chikte, "1971 War: Remembering First Air Combat to Liberate Bangladesh", in Eastern Air Command Book, *The 1971 War: The Eastern Saga,* 2022, pp. 152-158.

Air defence is an ongoing activity and has as much excitement during peace as during war. Recovering aircraft from dangerous situations or avoiding an unwanted situation are quite frequent in day-to-day operations.

place around that time. Some of the radars moved from the western to the eastern theatre. Moving radars with heavy vehicles and large convoys pose its own challenges which mostly go unnoticed and uncelebrated unless there is some accident en route. During the Kargil operations, many mobile radars were taken to high-altitude areas which were inaccessible. All the Transportable Radar Units (TRUs) were deployed in field locations for months together and faced all sorts of administrative and operational difficulties. Having spent almost eight months at a stretch in a field location as Commanding Officer (CO) of the unit during the Kargil operations, I can claim that it needs all kinds of leadership acumen and managerial skills to manage men and materials and keep them at operational readiness all the time. Similar mobility for an even longer duration, was undertaken during Operation Parakram when the units spent more than a year in the field.

Air defence is an ongoing activity and has as much excitement during peace as during war. Recovering aircraft from dangerous situations or avoiding an unwanted situation are quite frequent in day-to-day operations. Most of these situations do not find a mention despite being of tremendous operational importance, but if you ask any FC, he/she will have many interesting as well as important anecdotes to share. Some of the incidents that found traction in the media and highlighted the C&R part of operations are discussed below.

Operation Bandar or the Balakot strike was the kind of operational scenario which the operational crew is trained for, and ready to respond to, all the time. There can't be a better example of the high degree of readiness and response to fight at any given moment than this particular episode. No one other than a few of the top hierarchy of the Indian Air Force knew of this mission and all the FCs in various control centres were literally woken

up from their slumber in the middle of the night and asked to report to the Ops Room. Before this young bunch of professionals could realise what was happening, they were asked to handle the situation which had gone live. The response and professional handling speak highly of the training standards of the IAF. The crew in the Ops Room was to comprehend the situation in a flash and be in a position to provide control cover to the ongoing and subsequent missions. The story was the same in all the control centres and radar stations.

While everyone knows and remembers the story of Wing Commander Abhinandan, not many would know the exploits of Squadron Leader Minty Agarwal and her colleagues inside the Ops Room who spent substantial hours non-stop to control the endless missions, ever since the main Balakot strike mission took off. A large number of interceptors were scrambled to counter the response from the PAF. Those who understand the complicated nuances of the Ops Room functioning would understand the excitement and anxiety that would have engulfed the Ops Room. Particularly, Squadron Leader Minty who was controlling the mission of Wing Commander Abhinandan would have experienced restless and anxious moments till Abhinandan got back, despite the fact that she had handled the mission in a highly competent and professional manner. There were many like her whose contribution was immense in those hours of anxiety, uncertainty and unpredictability of the situation to follow.

In another incident, a Pakistani Naval Atlantique aircraft was shot down on August 10, 1999. Group Captain V S Sharma VM (Retd) was the FC and Commanding Officer (CO) of the radar unit at Naliya. He narrated his story of the eventful day that resulted in the first air-to-air interception and shooting down of an enemy aircraft after the 1971 War as follows:[9]

> I can distinctly remember there was no flying planned that day. Around five minutes past eleven, I heard two fighters taking off. I immediately

9. Excerpts of the Article, "Factual Account of Interception", at https://vayu-sena-aux.tripod.com/other-atlantique-factualAccount.html. Accessed on December 6, 2022.

realised that the situation is live for some activity across the IB. I also knew that Ashu, a young FC with just three months of experience as a fully Ops controller is alone on duty. I immediately ran to the cabin. It was an anticipatory scramble by ADDC. I immediately relieved Ashu and asked him to handle the communications with CRC. The mission had been ordered to climb to six km (~20,000 ft) and head North. RT contact couldn't be established on the main RT channel and mission was being vectored by ADDC. Subsequently, two ways RT contact was established on the standby GU RT Set and the mission was handed over to me. I asked the mission to descend to 500 metres to avoid pickup by PAF radars. Meanwhile, the target aircraft had gone back to GHA after the first intrusion close to the Northern boundary of the Rann of Kutch. The target parameters were, height 2.1 km (approx 7,000 ft AGL), speed 360 kmph (~220 mph) in a left turn.

I kept taking the Fighters northwards, maintaining more than 10 km East of the North-South section of the IB to establish CAP in the area for a subsequent intrusion. The mission was still on a northerly heading when the target intruded a second time, heading 220 close to the Northern corner of the IB threatening to cross the Southern section of the IB close to the sea. I asked the mission to head towards the general area of Koteshwar. This time, I decided to keep the mission about 20 km south of the Southern section of the IB. I ordered the mission to turn right on 270 and gave the target position as 1'O clock 40 km. To my utter surprise, Nanu called out contact with a black speck moving against the background of white clouds. I informed the mission that the target was still in GHA. He should go in for visual identification while maintaining westerly heading.

Nanu identified the target as a Pakistan Naval Atlantique, as it crossed the IB on a southerly heading. At this stage, all the blips had merged into one. Meanwhile, Nanu gained height to keep Bandy's tail clear, while Bandy kept closing in to see the tail markings of the intercepted aircraft. At this stage, the intruder was about ten km South of the IB on a steady easterly heading 090. I asked Bandy if he was still in contact with Target to which his response was affirmative.

At this stage, my response was, "Target well inside our border, identified hostile, clear to engage". My order to engage surprised Bandy, who rechecked if he had my clearance to open fire, to which my response was affirmative. As Bandy had dropped his speed to close to 300 kmph, well below the minimum speed for the missile launch, it took him almost a minute to achieve the firing parameters. I was relieved to hear from Bandy, "MISSILE GONE, LEFT ENGINE ON FIRE, BREAKING OFF 120".

When we look around the world, we find the IAF standing on a much more privileged and advanced pedestal. The IAF today is one of the best equipped Air Forces in terms of air defence equipment as well as trained manpower.

The real tense moments for me were after the mission had broken off, while the Atlantique was still flying on a single engine in a shallow left turn. I asked Bandy if he could see the aircraft. His response was that he could see smoke rising through the cloud top while the Atlantique aircraft wasn't visible being under clouds.

The flurry of activity to pacify hyperactive media and handling the sensitive matter at the diplomatic and military level, hit another dimension. A lot of heated arguments were exchanged and it was followed by a swift Pakistani military build-up in the area. The IAF helicopter, with media persons on board, was also fired upon.[10]

GLOBAL SCAN AND WAY FORWARD

When we look around the world, we find the IAF standing on a much more privileged and advanced pedestal. The IAF today is one of the best equipped Air Forces in terms of air defence equipment as well as trained manpower. With the IACCS now likely to cover the entire Indian air space and large numbers of indigenous radars and weapon systems, in addition to the advanced systems from friendly countries on the anvil, the air defence of the future looks formidable. One of the worries, however, that remains is

10. Ibid.

One area of concern that needs close scrutiny is the fact that all the FCs are now concentrated in IACCS nodes which reduces their exposure to other facets of operational and administrative issues at the flying bases.

that of the increasing number of drones and small-aperture Unmanned Aerial Vehicles/ Remotely Piloted Vehicles (UAVs/RPVs) being used for military purposes. This is evident in the Russia-Ukraine War where even the air bases were targeted. The present capability needs enhancement to counter this threat in terms of engagement procedures as well as weapons to neutralise. The Meher Baba competition organised by the IAF is a step in the right direction which needs to be extended to the operational domain, not merely in passive roles but active weapon and sensor roles.

Our radar coverage over the hills in all sectors is inadequate and, thus, a cause for concern. Considering the challenges of maintenance and sustenance of the present fleet of AWACS and Airborne Early Warning (AEW), the fleet needs indigenisation and enhancement to counter our adversaries who are much better equipped in this regard. This is particularly important since our surveillance requirements over the hills have now become critical.

One area of concern that needs close scrutiny is the fact that all the FCs are now concentrated in IACCS nodes which reduces their exposure to other facets of operational and administrative issues at the flying bases. Also, there would be fewer opportunities available to them in middle-level leadership roles. Today, the FCs, from flying officers to wing commanders, are undertaking virtually similar functional roles. It may be worth a try to introduce the 'Three Flight Concept' in the nodes, with each flight under a senior flight commander who would train and operate together. In addition, a Training Flight with dedicated resources under a Category Aye (Cat Aye) MFC as 'Flight Commander: Training', may be made to undertake a training role on a regular basis. These flight commanders can be made criteria appointments. This will lead to healthy competition, a dedicated training model and inculcate a sense of leadership.

Another area that needs the attention of the IAF is the representation of FCs in the hierarchy in C&R units. Despite being the 'line functionary' in AWACS, IACCS and radar units, they continue to operate only at the functional level. If we are to be at par with the world, we probably need to take lessons from the world powers in the functioning of these critical units. For example, General Lori Jean Robinson (four-star general), an air weapon controller or air battle manager (this term is used for FCs all over the world) is a retired United States Air Force general, who served as commander of the United States Northern Command (USNORTHCOM) and commander of the North American Aerospace Defence Command (NORAD) from May 2016 to May 2018.[11]

Fig 6: General Lori Jean Robinson

Source: www.af.mil/About-U /general-lori-robinson/

11. "Biography of General Lori Robinson", at www. Af.mil/About-Us/Biographies/Display/Article/108119/general-lori-j-robinson. Accessed on December 4, 2022.

She was the first female officer in the history of the United States armed forces to command a major Unified Combatant Command. Robinson previously served as commander of the Pacific Air Forces; air component commander for the United States Pacific Command; and executive director of the Pacific Air Combat Operations Staff, Joint Base Pearl Harbour-Hickam, Hawaii. She was the first woman air battle manager to command an AWACS squadron and an AWACS base before she moved on to higher joint Services commands. The IAF has a lot of catching up to do in this regard, as the AWACS controllers in the IAF do not even get the appointment of the flight commander in an AWACS squadron. The rotation and deployment policy of the FCs in the AWACS squadron, therefore, needs a serious review.

If there is anyone who has intricate knowledge of the multiplicity of air operations and combat leadership other than the multi-domain fighter pilot, it is the FC. Having done two full tenures of Directing Staff (DS) at two staff colleges and two tenures in Directorate of Air Staff Inspection (DASI) and interacted with the entire spectrum of IAF officers, I can say this with conviction. The work environment and handling of varied operations on a daily basis expose the FCs to all kinds of air operations. The French Air Force recognises this potential of the FCs as their Centres de Détection et de Contrôle (CDC) (akin to our IACCS nodes) are commanded by the air defence pilots and FCs in rotation. Also, whoever assumes command, first works as deputy commander in the same CDC.

The Ops Room functioning is a unique combat drill which needs to be honed with sustained training on an everyday basis. The COO in an IACCS node is an FC with approximately 18-20 years of experience and needs to be assigned a wider operational role. Similarly, all the FCs need to be trained to take on more responsibilities for air battle management across the spectrum of operations. The term 'air battle manager' is used for the FCs or weapon controllers in all major Air Forces. In my personal opinion, based on the exposure around the world, the FCs in the IAF are as professional and as capable as in any other Air Forces, if not better. And, therefore, they need to be optimally utilised for their potential.

CONCLUSION

Air defence has progressed very rapidly in the last decade in terms of concept, equipment, quantum and procedures. The complexity of threat is also on the increase, with a spectrum comprising small UAVs, drones and surface-to-surface missiles, besides highly capable aircraft operating at all altitudes. The demand for the operational crew is also increasing manifold in view of the complexity of threats and the induction of varied modern systems in large numbers. The challenges for the IAF, therefore, are also many, to maintain and sustain the modern as well as legacy systems and train the crew to deal with these challenges. I am sure the IAF is well equipped to face these challenges in its stride, as has been demonstrated by its over the years of its modernisation drive.