Army Air Defence in India

Naresh Chand

Rise of Military Aviation

Air defence or anti-aircraft artillery (AAA) as it was earlier called, originated with the threat of airborne platforms like airships and aeroplanes being used for supporting warfare. Mankind had been trying to fly through the ages but the first pragmatic effort was in the form of airships. The 19th century saw many attempts for adding propulsion to balloons. In 1872, the French naval architect, Dupuy de Lome, launched a navigable balloon which was developed during the Franco-Prussian War for communications. The role of airships as bombers had been recognised in Europe in the early stages of airship development. On March 5, 1912, Italian forces became the first to use airships for reconnaissance behind Turkish lines. It was World War I (WW I) that marked the airship's real debut as a weapon. Albert Caquot designed an observation balloon for the French Army in 1914 which was used by the Allied forces. The Germans, French and Italians operated airships for scouting and tactical bombing roles early in the war. There are reports of use of anti-balloon artillery in the US Civil War and the Franco-Prussian War. As balloons were found to be vulnerable to fire, their military use was discontinued in 1917. However, tethered balloons are still being selectively used for surveillance and for the air defence of airfields. The first powered flight was flown by the Wright Brothers on December 17, 1903. With the development of the aircraft, its military employment soon caught on.

WW I

Before the start of the WW I, no country had built an aircraft specially designed for the military role; however, many countries had experimented in bombing, firing guns and reconnaissance. In spite of many sceptics, efforts were on to

Lieutenant General **Naresh Chand** (Retd) is Senior Technical Group Editor, *SP's Aviation*, New Delhi.

use aircraft for military purposes. Some of the early efforts to explore their use in the military role took place in Italy in April 1909, when Wilbur Wright was brought to Italy to demonstrate his Military Flyer. He trained Italy's first pilot, Naval Lieutenant Mario Calderara. Airplanes and airships were used for the first time in warfare during the Italian–Turkish War of 1911–1912. In March 1912, Captain Piazza made the first photo-reconnaissance flight in history. Soon, other countries followed and the French Army bought its first planes in 1910. They began to install armament in reconnaissance craft in 1911 and started trials with aerial bombing. The UK soon followed suit. In Russia, Igor Sikorsky built the first four-engine plane that was the forerunner of the multi- engine strategic bombers of WW1. The US also tried to catch up by carrying out limited experiments in aerial bombing and operating from a ship. On November 14, 1910, Eugene Ely of the US made the first take-off from a warship and an US Army officer, Captain CD Chandler, fired a 750-rounds-per-minute, air-cooled recoilless machine-gun successfully. The European countries led the way to develop military aircraft as compared to the US. In 1912, the US had 193 licensed pilots as compared to 968 in France. During WW I, the European countries started taking the use of aircraft for military purposes seriously, and later on, the US joined the effort.

AAA During the World Wars

At the beginning of WW I, there was a requirement of AAA but at that time, the problems of land warfare were more overwhelming than a few aircraft carrying out an insignificant aerial attack. The Germans had built a few guns designed for the anti-aircraft (AA) role before WW I and, thus, began the war with 18 AA guns. Other countries gave this little attention and, thus, most of the early AA guns were artillery guns modified to elevate higher and traverse faster through a wider arc than standard artillery pieces. The task of the AA gunner proved much more demanding than that of the normal gunner as the target was always moving and could manoeuvre in three dimensions simultaneously. The AA gunner had to continuously adjust for range, lead angles and elevation. However, there was no guarantee of hitting the target as once the projectile left the barrel, there was no possibility of guiding it and a number of external forces like gravity, weather conditions, drop in muzzle velocity and change in flying parameters acted upon it. To some extent, these errors were made up by having a high rate of fire but the technology of that period was not adequate to meet the newly developing air threat.

However, the British and Germans increasingly used air power during WW I and both sides bombed each other's cities. The Germans launched 43 aircraft

on London during their last major raid on May 19, 1918, against the British who employed 84 fighter sorties and 126 guns that fired 30,000 rounds. In November 1918, the British used 480 anti-aircraft guns and 376 aircraft in the defence of Great Britain. The majority of air operations during WW I were in support of ground forces. New technologies which were developed were sound-detection systems, searchlights, optical range-finders and mechanically timed fuses. Between WW 1 and WW II, there was hardly any development in AA gun technology. In 1928, the US adopted the three-inch M-3 gun as a standard AA gun which had an effective ceiling of 21,000 ft and matched the aircraft of that time. Meanwhile, some new innovations in gun and ammunition design like removable barrel liners, automatic breech mechanisms and continuous fuse setters, improved the AA guns. However, advancements in aviation during the 1930s, like higher speeds, left the three-inch gun obsolete. The ding-dong battle between aviation and AAA for supremacy continued and larger calibre guns like the 90 mm with higher muzzle velocity and higher rate of fire were adopted. The Germans selected the 88 mm, the British the 3.7-inch (94 mm) and the US, the 90 mm. Detection of an aircraft was a major problem till the British developed the radar which became a key component in the evolution of AA weapons.

New innovations in gun and ammunition design like removable barrel liners, automatic breech mechanisms and continuous fuse setters, improved the AA guns.

British AAA

During both the wars, the British were severely affected by hostile bombing, with London being the main target. It led them to believe that there was no direct defence against the bombers. They, thus, focussed on developing the bomber that would deter the enemy due to the punishment it could deliver and neglected any defensive effort or development of fighter aircraft till 1937. During early 1938, the British had only 180 anti-aircraft guns larger than 50 mm which increased to 1,140 during the Battle of Britain. By the end of September 1940, the British claimed that about half of the German bombers turned back due to AA gun fire. Even if this claim seems exaggerated, the gun fire certainly forced the bombers to fly higher and deterred the crew by reducing the accuracy. AA guns were also the main defence against night attacks as night fighters were still in their infancy. By the end of 1940, AA defences claimed 85 percent of the British night kills. Some

problems were perennial like recognition of friend or foe which persists in spite of the advancement in technology. In fact, the first British kill was regrettably a friendly aircraft, three days after the declaration of war. The first German kill claimed was on October 19, 1939. The gun laying radar came into service in October 1940. There was a mix of gun calibres ranging from the 3.7 inch, 3 inch, 37mm, and 40 mm to two-pounder guns. However, the 40mm calibre was the clear winner, and starting with a holding of 41 guns in 1942, Britain had on its inventory 917 guns by April 1943. Developments in British technology converted fuses from powder to mechanical, introduced flashless propellants and automatic fuse setters all of which improved accuracy and increased the rate of firing. By this time, electric predictors were also introduced.

Allied AAA proved inadequate as was obvious from the results in Norway, France and other theatres but what emerged clearly was that air power had come to stay in future wars and so had AAA. By the end of the war, jet propulsion came into being which increased aircraft performance manifold and required a *de novo* look at the development of AAA.

The Advent of Radar

During WW II, impressive strides were made in the development of radar by the Allies which contributed greatly to their victory. After the war, use of radar spread to other areas like civil aviation, marine navigation, space, police, meteorology and medicine.

Early Pioneers

In 1887, the German physicist Heinrich Hertz began experimenting with radio waves in his laboratory. He found that radio waves could be transmitted through different types of materials, and were reflected by others, such as conductors and dielectrics. In the early 1900s, the German engineer Christian Hülsmeyer invented a simple omni-directional detecting device. Hertz was the first who succeeded in generating and detecting radio waves. Marconi followed up this research and his article, published in 1922, included circuit diagrams showing the equipment he used for his experiments. His talk on the subject to a joint meeting of the Institute of Radio Engineers and the American Institute of Electrical Engineers in New York City on June 20, 1922, is considered by many as a landmark in the development of radar. Many countries were pursuing research on radar. Some landmarks in the evolution of radar were the development of pulse radar (which could give range and velocity which a continuous wave radar could not), the

invention and development of the magnetron which provided very powerful transmission in a compact manner, the centimetric radar which allowed the detection of smaller objects and reduced the size of the antenna, and many more. Radar was the most significant development during WW II and became a key player in the AA weaponry. Radar also provided today's microwave which no modern household can do without.

By dominating the battlespace and becoming all prevalent, modern air power has become truly a battle winning factor.

Development of Air Power post-WW II

The introduction of jet propulsion for military aircraft gave a quantum leap to the capabilities of air power by increasing its speed, acceleration and altitude which was a great asset in aerial combat. Many countries had been carrying out research on jet propulsion for a very long time but the British design was more versatile and, thus, universally accepted. Its manufacture started in the USA under licence, and by 1950, most of the military aircraft were being fitted with jet engines, except for transport, liaison and some other special types of aircraft. Technology has contributed immensely towards the development of aviation as a whole and has touched all aspects to include aeronautics, avionics and armament. The result has been that the modern fighter navigates more accurately; its armament is more lethal and accurate, it can operate in all weather conditions, has better survivability, can carry out precision attacks beyond the visual range and has stealth capability. Network-centric capability will further synergise air power. Air power now includes other air breathing platforms like helicopters, unmanned aerial vehicles (UAVs), unmanned combat aerial vehicles (UCAVs), cruise missiles, surface-to-surface missiles, etc. Strategic missiles are generally considered separately under ballistic missile defence (BMD). By dominating the battlespace and becoming all prevalent, modern air power has become truly a battle winning factor.

From Guns to Missiles: Evolution of AAA post-WW II

The US, Russia and Europe led the development of weapon technology, including AAA, with their own perceptions of national interest and threat. As the modern air threat included other airborne platforms, the term AAA was replaced by air defence (AD). After WW II, US forces were rapidly demobilised and national policy was based on tighter defence budgets and faith in the atomic bomb. The US had

the means to deliver it on the Soviets as they had sparse air defence and large areas to cover. One bomber with an atomic bomb could do much more damage than what hordes of bombers did during WW II. This optimism led to the neglect of air defence. The US Army tried to replace the .50-calibre machine but failed. Subsequently, it did field an upgraded 40 mm anti-aircraft gun named Duster, two of which were mounted on an M-41 chassis and linked with the fire control radar. Later on, radar was removed to reduce cost. Later, the 37-mm Gatling gun named Vigilante was developed but was not found suitable. It then tried the 75 mm Skysweeper but this was soon replaced by surface-to-air missiles (SAMs). The 20mm Vulcan six-barrel gun was electrically rotated and had a rate of fire of 7,200 rounds per minute, and was selected by both the US Army and Air Force. However, the US based AD more on missiles and aircraft. In the early 1980s, the army tried a German mobile system called Gepard which was also rejected. It then tried to develop the Sergeant York by mounting twin 40 mm Bofors guns and a radar on an M-48A5 tank chassis. This was also cancelled in 1985. The Soviets, on the other hand, had great faith in guns and went for multi-barrel guns with a very high rate of fire like the ZU 23mm twin barrel (rate of fire of 2,000 rounds per minute) and ZSU 23mm four barrel Schilka (rate of fire of 3,400 rounds per minute). The Schilka is a mobile radar controlled system, capable of firing on the move. Both these were effectively used by the Arabs during the Yom Kippur War of 1973. Another noteworthy mobile system developed by the Soviets was the gun /missile system Tangushka which has radar controlled 30mm twin guns and missiles. The Swedish developed the L-60 gun which was the mainstay of the Allies during WW II. It was succeeded by the L-70 which truly was the first modern AD gun. It is radar controlled and is still in service with many countries, including India. Other noteworthy guns produced in Europe are the Skyguard and Skyshield. Guns have reached a plateau as far as operational capability is concerned but there is scope for developing more lethal ammunition like ammunition with the radio fuse or the AHEAD (advance hit efficiency and destruction technology) ammunition of Rheinmetall. It contains 152 heavy tungsten metals, spin stabilised sub-projectiles and is ejected by a time fuse, and very effective against small targets.

Surface-to-Air Missiles

The word 'missile' originates from the Latin verb *mittere* which means 'to send'. Germany is the pioneer in the development of missiles and their V-1 and V-2 are well known. The development of SAMs has greatly improved the effectiveness

of surface-based AD weapons. Many countries are developing SAMs, with the US and Russia at the forefront. The early missiles were guided by a command system in which one radar unit acquired and tracked the target, a second tracked the missile, and a computer calculated missile data for interception. Generally, the SAMs fell into three categories: missiles with very long ranges like the Nike series based on static launchers, mobile missile systems like the Russian Kvadrat, and shoulder-fired missiles like the Stinger of the USA and the Igla of Russia. The Nike Ajax was the US' first operational SAM with a range of 40 km. In 1946, the US was still going in for very long range missiles like the Wizard and Thumper, with ranges of over 550 miles, but later, they were put on hold. The policy for division of responsibility between the army and the air force in the US gradually veered towards the ranges and roles where shorter range missiles were used for guarding the army assets with the army, and the long range missiles with the air force. The first SAM to enter service in Britain was the Bloodhound in 1958. These first-generation missiles had command guidance systems and were large in size. The French worked on the PARCA and MATRA R422-B, and the Swiss (Oerlikon) built the RSD 58. The Soviets were also making progress with SAMs which were evolved from the German WW II programmes. The first Soviet SAM, the SA-1, was a German Wasserfall with command guidance and became operational in early 1954, the same year that the US Army deployed the Nike Ajax. Its successor, the SA-2, was designed to defend against high-flying strategic bombers. The SA-2 first achieved fame by knocking down an American U-2 over the Soviet Union in the spring of 1960 and bringing down another over Cuba in October 1962. Russia has been in the forefront of SAM development with about 24 types in the ground version (from SA-1Guild to AA-24Grinch) and approximately 14 types of the naval version (from SA-N-1 Goa to SA-N-20 Gargoyle). In the US inventory, two missile systems stand out, that is, the MIM-23Hawk (homing all the way killer) and its latest version, the Hawk XXI. The other is the Patriot series of missiles which is truly a modern SAM and became operational during the first Gulf War. Its variants are the Patriot, Patriot Advanced Capability (PAC-1) PAC-2 and PAC-3. The MIM-104 Patriot has replaced the Nike Hercules system for the high to medium air defence role and has succeeded the MIM-23 Hawk system in the medium tactical air defence role. The MIM-104 Patriot combines several new technologies, including the phased array radar and track-via-missile guidance. The PAC-3 has hit-to-kill technology and does not use any explosive. It can destroy a tactical ballistic missile by sheer kinetic energy and accuracy. The PAC-3 missile segment enhancement is part of the ongoing development being

The boundary of responsibility between the air force and the army gets somewhat blurred due to lack of an effective agency to synergise the national resources.

undertaken and most likely it will be the main missile for the medium extended air defence system. After the SA-2, the prominent Soviet SAM was the Kvadrat (SAM-6, which India also has and is now obsolete) which played a key role in the Yom Kippur War of 1973. Other systems are the S-300 (SA-10) which is claimed to be equivalent of the Patriot, OSA-AK (SA-8), BukM (SA-11), S-300v (SA-12 a and b), Tor (SA-18) and Pantsyr(S-1). All these systems are highly mobile and effective. The US' shoulder-fired system was the Redeye which was not that successful and was succeeded by the Stinger. The most prominent Soviet shoulder-fired systems are the Strela (SA-7) and Igla(SA-18). The Europeans have the Aster series and the Israelis have the Spyder (the Indian Air Force is acquiring it), and Arrow among others. Guidance systems in vogue are radio command, active radar terminal homing, semi-active terminal homing, infrared (IR), track via missile and a combination of some of these.

Indian Perspective

In India, the IAF has overall responsibility for the AD of the country but it is jointly executed by the army and air force. The army is responsible for the point defence of the strategic assets of the country like nuclear plants, air bases, radar stations, etc apart from the AD of the field army. This implies that the army should be holding guns, and quick reaction short range and shoulder-fired missiles for point defence of strategic assets, but for some reason, the army holds only guns and the missiles are with the air force. In fact, the current OSA-AK quick reaction short range missile which the air force is holding for the AD of the key air bases, is mounted on an 'A vehicle' and is suitable for mobile warfare when only a transportable system is required. In fact, the army is holding the same system to support its armoured formations. Thus, the boundary of responsibility between the air force and the army gets somewhat blurred due to lack of an effective agency to synergise the national resources. The army is responsible for AD of the field army up to medium level and, thus, holds guns and missiles accordingly. The air force is responsible for the area AD of the hinterland and holds medium range missile systems for it. It also has AD aircraft. After the experience of the last six decades, it is essential now to review the division of responsibility between the

Ballistic Missile Defence

India is surrounded by neighbours like China and Pakistan which pose various types of nuclear missile threat, ranging from the cruise missile to the intercontinental ballistic missile. India at present lacks any kind of air defence against even short range ballistic missiles (SRBMs) or cruise missiles. It does not even have a missile system with a range of more than 25 km. The Advanced Air Defence programme holds the obsolete Kvadrat missile system which belongs to the late 60s. The Indian Air Force (IAF) has signed a contract to acquire the Spyder missile system but it is a low level system with a range of about 15 km. The Pechora missile system is obsolete and its successor is not known yet; however, there was a media report that a memorandum of understanding (MOU) has been signed by the Defence Research and Development Organisation (DRDO) and Israel to develop a medium range SAM of about 70 km. The surveillance systems are all geared towards the northern and western borders, though Israeli radars like Green Pine do provide a semblance of surveillance at the national level. The arrival of the airborne warning and control system (AWACS) is certainly good news and with the induction of the remaining AWACS, surveillance needs will be adequately addressed. India needs a ballistic missile cover but considering the cost and technologies involved, it will certainly remain a wish list. However, that should not deter India from making a modest beginning to counter cruise missiles and SRBMs. DRDO has claimed success in a series of missile intercepts in their Advanced Air Defence programme, starting from November 2006. The first intercept was at 50km and the last one was on March 6, 2009, at an altitude of 75km. The following pragmatic approach is suggested for India:

- A fully developed BMD will have a integrated layered system to destroy a ballistic missile in its boost, mid-course and terminal phases. India should concentrate on the terminal phase and acquire proven systems like the Patriot or Arrow. Meanwhile, DRDO can continue to progress the development of the Advanced Air Defence programme.
- Ground-based weapons of the Advanced Air Defence programme and IAF should be modernised on priority. The army should go for a missile system of 70 km range so that it can augment the BMD in its terminal phase, especially in the forward battle zone.
- All resources of the defence forces and civil authorities should be integrated.
- India may have to join other countries like Japan and South Korea for an effective BMD. India has signed with the US a 10-year "US-India Defence Relationship—The Defence Framework". Clause H of the agreement seeks to "expand collaboration relating to missile defence."

It appears that in spite of ever tightening of procurement procedures, all tenders at some stage run into the quagmire of allegations of corruption, and get stalled.

army, air force and all other agencies like the civil aviation, taking into account the new threats of asymmetric warfare and cross-border terrorism.

Army Air Defence (AAD) in India

The army inherited the AD system from the British who left L-60 guns of WW II vintage when they left India. Post-independence, air power was still in its infancy in India as well as across its borders. The army was, thus, totally clueless as what to do with its AD inheritance, hence, status quo was maintained. However, as the L-60 gun was becoming obsolete, the search for its successor began and the L-70 was selected. It was a very good radar controlled gun of its time and its manufacture was undertaken by the ordnance factory and the fire control radar's manufacture was carried out at Bharat Electronics Limited. The 1965 War with Pakistan somewhat failed to trigger any effort to modernise AD e.g. L-60 towed guns were still supporting armour operations due to the lack of a mobile system. Being part of (rather under) artillery was a handicap as the gunners perceived AD through their perspective and serving in an AD unit was considered a black mark in one's record. There was no permanent AD officers cadre and the Territorial Army's AD regiments somewhat muddied the blue skies. As late as the 1980s, AD regiments were holding field artillery ammunition for practising observation post end procedures by AD officers as that was considered their bread and butter. During 1971, one commander of the Artillery Brigade ordered that fire would be opened on hostile aircraft only after taking his permission. In an air battle, where the time is counted in seconds, such an order showed complete ignorance of the air battle. Fortunately, the war record of the AAD in 1971 was glorious and earnest effort was undertaken to modernise it.

The Golden Era

One of the key hurdles to modernise was as how to predict the air threat. Since no concrete reply was forthcoming from military operations or the air force, AAD decided to form its own air threat with the help of the then Chairman of the Joint Intelligence Committee, K Subrahmanyam. This air threat became the basis of modernisation and has stood the test of time. Thus, the 1980s saw a plethora of modern AD systems becoming part of the inventory. The pace of induction of the L-70 gun system was

accelerated. The erstwhile Soviet Union came to India's rescue and offered very good systems at very modest terms. The L-70 gun system took care of the point defence but the field army had been completely neglected. The ZU-23 twin guns and the Strela, and later on the Igla shoulder-fired system were inducted for the infantry divisions. The armoured divisions got the Schilka four-barrelled all-weather mobile system for point defence, OSA-AK mobile all-weather system to take on the attack helicopter threat, Strela 10-M mobile fair weather system for independent armoured brigades and Kvadrat all-weather system for area AD of the strike corps. All the units became regular, more units were raised along with the formation headquarters and a complete overhaul of AAD took place by the early 1990s.

Current Status

It appears that post the 1990s, time has frozen for AAD and except for limited Tanguska and Flycatcher fire control radars, there has not been an iota of modernisation. The L-70 gun which is the mainstay for point defence is more than four decades old and all other equipment is either becoming obsolescent or is obsolete. The successor to the L-70 gun has got entangled in the single vendor syndrome and probably a fresh Request for Proposal (RFP) will be issued, further delaying the process. DRDO has not been able to deliver any of the AD projects. Their showpiece missile projects, the Akash (to replace the Kvadrat) and Trishul (to replace the OSA-AK), have not fructified and, in any case, their operational characteristics are bordering on obsolescence due to more than two decades of the development phase. There is no successor to the Schilka in sight although at some stage, the Tangushka was selected but for some reason, only a few were acquired and there has been no further progress. It appears that in spite of ever tightening of procurement procedures, all tenders at some stage run into the quagmire of allegations of corruption, and get stalled. The process has become king and modernisation is being sacrificed at its altar. A very strong and resolute leadership is required to steer the ship of defence modernisation through the maze of rules, regulations and the quagmire of alleged corruption.