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C4ISR ARCHITECTURE FOR AN INTEGRATED AIR DEFENCE AND BMD- NECESSITY AND FEASIBILITY

Air Marshal Daljit Singh, PVSM, AVSM, VM (Retd)*

Introduction

Historically, technological developments have changed the way the wars have been fought. From dropping small bombs employing biplanes during early years of World War I, to the massive bomb loads of two tons dropped at night over London, by the German Zeppelins during the later period of the World War, the offensive strike capabilities have been advancing exponentially to conduct aerial attacks. During World War I, technology could not match the perceived strategic and operational concepts. With significant developments in aviation technology, radars, electronic navigation, propulsion systems and communication network, World War II saw massive improvement in bomber and fighter forces which delivered thousands of bombs during day and night, and which culminated in the employment of the first nuclear bomb on 06 August 1945 that struck the city of Hiroshima, killing nearly eighty thousand people.[1] To counter the air strikes, Air Defence Systems were developed by both the RAF and the Luftwaffe (German Air Force), which were based on radars, direction finding instruments, searchlights, anti-aircraft artillery, balloon barrages, visual observers and fighter aircraft. The first British integrated Air Defence network known as Chain Home (CH) or Dowding System was deployed along the east coast, with the Sector

Control Rooms established as Command and Control centers and they provided enmeshed data from diverse types of sensors and directed the 'shooters' for kills. The Luftwaffe also established an effective integrated air defence network with Operations Direction Centers to control the AAA, searchlights, and radar equipped fighter interceptors. Further technological improvements took place during the cold war period in propulsion technology, guidance systems and radar detection capabilities, and major nations like the erstwhile Soviet Union and the USA developed superior Surface to Air Missiles (SAM) like SAM II and Nike Hercules II. The first victim to SAM II missile during hot war was the F4 Phantom fighter being shot down on 24 Jul 1965, during the Vietnam War. The Americans lost 160 Phantoms to the SAM IIs by the end of 1965. This episode triggered the attack forces to develop Precision guided munitions (PGM) with standoff weapon delivery capability, Laser designated Pods (LDP), Anti-Radiation Missiles (ARM), Hunter-Killer Missions for Suppression of Enemy Air defences (SEAD) and Airborne Early warning and Control Systems (AEW&C). Electronic Warfare regained importance during this period to effectively counter Integrated Air defence network. In the meantime, significant development took place in the fields of cruise missiles and ballistic missiles which were first employed during World War II by the Germans as V1 and V2rockets, respectively. The V2 had an effective range of 350 km with one ton warhead, and circular error of probability (CEP) of 10 km. Nearly twenty thousand such rockets were launched with devastating effect on morale of the population. Since then, there have been massive improvements in the capabilities of the ballistic missiles and cruise missiles. They gained prominence as weapons of choice during the Gulf Wars, when the Allied Forces copiously employed cruise missiles and Iraq launched many Scud Missiles against Israel to lure other nations into the conflict. During the cold war period itself, when considerable number of nuclear capableballistic missiles were fielded by the Warsaw Pact nations, the Americans and other NATO allies, it

was evident that traditional sensors and shooters were incapable of effectively neutralising ballistic missiles, due to their high speed, low radar cross section (RCS), altitude and ranges. To ensure some level of deterrence, specific Ballistic Missile Defence Shields were developed by the erstwhile Soviet Union and the USA. With further technological advances in sensors, guidance technology and delivery accuracy, more theatre ballistic missiles and cruise missiles are now being employed as instruments of choice for attacks,as their employment does not cause own human attrition. During the ongoing Russian- Ukraine Conflict, conventional ballistic missiles have been used extensively by both sides. The extensive employment of ballistic missiles by the Iran backed Houthis during attacks on the UAE and Saudi Arabia in 2020, points towards this trend of weapon employment even by terrorist organisations. Many nations have, therefore, considered establishing 'Air and Missile Defence' infrastructure to optimise employment of resources, as the capabilities of AD sensors and shooters are improving and overlapping to tackle both air and missile threats. India also faces a serious threat of theatre missiles, cruise missiles, in addition to standoff precision guided munitions. A lot of developments are taking place in India to improve Air Defence and missile defence capabilities. It is, therefore, important to analyse whether it would be prudent to integrate these systems for their optimum employment and whether it would have any drawbacks

Indian Operational Environment

India faces two nuclear capable adversaries with significant arsenal of ballistic missiles, cruise missiles and modern fighters, capable of standoff PGM attacks. China has been developing advanced ballistic missiles with multiple independently targetable Re-entry Vehicle (MIRV) capability, maneuverable anti-ship missiles and hypersonic glide/cruise missiles. Its DF series of ballistic missiles has ranges to attack any target in India. The restructured PLARF Rocket Force has formidable

arsenal of ballistic and cruise missiles, and it continues to grow its inventory of road-mobile DF-26 intermediate range ballistic missiles (IRBMs).[2] PLAAF continues to increase its inventory of fourth generation fighters,and it has also fielded fifth generation J-20 stealth fighters and FC 31 stealth fighter is being developed for export as well as for Naval operations.[3] PLAAF intrusions in the Ladakh region continue off and on. Pakistan continues to engage India by asymmetric means, while it continues to modernise its Armed Forces. There have been significant developments in Pakistan to produce theatre ballistic missiles, cruise missiles and UCAVs.

Indian Air Defence Setup

The Government has entrusted IAF with the responsibility of the Air Defence of the Indian airspace. Therefore, control of all AD weapons is exercised by the IAF. Army has substantial number of ground based AD weapons to protect their war waging assets and specified Vital Areas/ Vital Points (VA/VP). Protection of Naval shore based assets is the responsibility of the IAF, while the AD protection of the assets at sea is the responsibility the Navy, which can be supplemented by the IAF early warning inputs. Organisationally, the IAF has five operational Commands, and each command has Air Defence Control Center (ADCC) which exercises control over all Air Defence activities within its area of responsibility (AOR). The IAF has a well-established, networked Integrated Air Command and Control System (IACCS) which is the nerve center for airspace management and weapons control. At present, nine IACCS Nodes are operational covering the entire Indian airspace[4]. Most of IAF radars are integrated with the IACCS to provide Composite Air picture of the air space. Civil radars and Airborne Warning and Control System aircraft (AWACS) are also integrated. The Army and Navy sensors are planned to be integrated with IACCS for exchange of information and control orders. The radar inputs are analysed and fused

to provide a composite air picture, which is shared with weapon control centers. There are many IACCS nodes spread over the entire nation that provide enough redundancy and resilience against attacks. The Surface to Air Guided Weapons (SAGW) are being integrated into the IACCS for effective and unambiguous target designation and execution. The IAF has been steadily inducting considerable number of modern radars with 4D detection capability. The venerable legacy THD 1955 long Range radars have been operating well and they are likely to be replaced by High Power Radars (HPR) that would have digital, active electronic steering array (AESA) technology with detection ranges of up to six hundred kilometers. There are also plans to induct 'Mountain Radars'[5]. Medium Power radars initially imported from Israel are now being manufactured in India as 'Arudhra'. The Indian made 'Rohini' 3D radar, Low Level Tactical Radar (LLTR) and low level light weight transportable radars are modern digital radars which are networked to the IACCS. The IAF has adopted multilayered Air Defence Systems concept to provide multiple tier protection with deployment of LRSAMS, MRSAMs medium range SAMs, Akash short Range SAMs, SPYDER QRSAMs, shoulder fired SAMs and anti-aircraft artillery. The IAF continues to employ the legacy SAM IIIs and SAM VIIIs effectively. The formidable S-400 SAMs are getting inducted, and the contract is signed to induct five Regiments comprising of 40 launchers, C2 elements and other support systems. The Indian Army has many legacy SAMs; however, MRSAM and Akash short range SAMS have been inducted and plans include additional MRSAMs, VSHORADS, Gun & Missile systems and AA Guns.

Indian BMD Project

Monitoring rapid developments of ballistic missiles by China, acquisition of M 11 SSMs by Pakistan, and threat by the Pakistani Foreign Secretary on 31 May 1999 to use 'any weapon' in the arsenal, during the Kargil Operations, prompted India to accelerate development of the Indian

Ballistic Missile Defence System.[6] BMD program also referred as Program AD (PGAD), was spearheaded by RCI, DRDO[7] and Defence Research and Development Laboratory (DRDL) developed the mission control software. [8] The components of the BMD include Long Range Tracking Radar (LRTR) (initially acquired from Israel as 'Green Pine' Radar and later produced indigenously), Multi-Functional Control Radar (MFCR), intercept missiles and Command and Control Centers[9]. Two types of interception missiles have been developed to undertake interception at various stages of ballistic trajectory. Prithvi AD (PAD) missile intercepts Ballistic missiles at exo-atmosphere at an altitude of 50-80 km and Advance Air Defence (AAD) missile is developed for interception in endo-atmosphere up to an altitude of 30 km. Phase 1 of development has been completed in April 2019, which provides capability to intercept ballistic missiles of 2000 km range.[10] Phase II of the development with more advanced missiles is under way to achieve the capability to intercept 5000 km range BMs. 'The deployed system would consist of many launch vehicles, radars, Launch Control Centres (LCC) and the Mission Control Centre (MCC). All these assets are geographically distributed and connected by a secure communication network.'[11] The MCC predicts the missile trajectory and designates the LCC to undertake interception. It would also calculate the interception probability and decide to launch more missiles to ensure success. 'IAF as the lead service for providing BMD protection of Delhi NCR has inducted one Multi-Function Fire Control Radar (MFCR) in NCR and one Long Range Tracking Radar (LRTR) is being deployed'[12]. These Radars are being operationalised in coordination with PGAD, DRDO and are being operated and maintained from internal IAF resources.[13] The Indian Naval Ship 'Dhruv' with capability to detect ballistic missiles and satellites, has been commissioned on 10 September 2021 as a maritime component of Anti-Ballistic missile detection system.[14]

Other Likely BMD Sensors

National Technical Research Organisation (NTRO) has been accorded sanction to procure two Very Long Range Tracking Radar (VLRTR) units as part of Missile monitoring System, to be manned by the IAF.[15] The systems are likely to have achieved the operational status by now. As the name suggests, these radars are likely to have much higher ballistic missile detection ranges.

High Altitude Pseudo Satellite System. Hindustan Aeronautics Ltd (HAL) has initiated a Project to develop High Altitude Pseudo Satellite System (HAPS), which would be solar powered, light weight airborne system, capable of staying afloat at an altitude of around seventy thousand feet for two months[16]. This system is perceived to bridge the gap between UAVs and satellite capabilities for surveillance and communications. This project commenced with funding by HAL and the project has now received the Government approval[17]. The system is likely to be developed in three to four years' time. The HAPS is a potential platform to detect ballistic missiles as well as other airborne objects. It could also be well exploited as communication relay station and Sigint sensor. The system could be integrated with IACCS to enhance overall situational awareness. NAL too has unveiled its own HAPS program in April 22, during Wings India Show at Hyderabad.

Space Based Sensors. In April 2019, the Government has sanctioned establishment of Defence Space Agency (DSA), to command the space assets of the Army, Navy, and Air Force, including the military's anti-satellite capability. The agency is also to formulate a strategy to protect India's interests in space, including addressing space-based threats.[18] Space provides excellent avenue for fielding sensors to detect ballistic missiles, hypersonic projectiles, and continuously gather Sigint data and geographical data. These inputs can be usefully integrated with other sensors to persistently track ballistic missiles and hypersonic glide or

propulsive vehicles. DRDO and private industries are keenly investing in space technologies, and we can see rapid progress in future, in this area.

Analysis

Recent operational trends indicate more employment of ballistic missiles, cruise missiles and attack UAVs, especially during the opening stage of confrontation. Even some terrorist organisations have employed these assets to create terror. China has significant arsenal of these missiles and dedicated Rocket Force has been organised to employ these weapons copiously. Pakistan has been developing cruise missiles and 'tactical ballistic missiles' to counter advancing Army formations. All modernising Air Forces like PLAAF and PAF have formidable bomber (PLAAF) and fighter force capable of attacking with standoff PGMs, Anti-Radiation Missiles (ARM) and air launched cruise missiles. Low level fighter attacks by overflying the target would be rare considering the lethality of the present AD systems. However, terminal AD assets must have the capability to neutralise the PGMs, cruise missiles and other types of munitions before they hit the target. Attack by small UAVs carrying explosives, against unprotected targets will increase, especially by rogue elements, as it was experienced at Jammu Airfield in Jun 2021. Effectiveness of AD Guns based CIWS against such attacks needs to be established before we go in for their massive induction.

India has well networked and integrated Air Defence set up, which has achieved good capability for continuous air surveillance and airspace management. It is a matter of time that all ground based weapons would also be integrated for improving the 'shooter cycle' and optimizing the C2 resources. The IACCS being indigenous system has great flexibility in upgrading the Command and control architecture and integrating future sensors, including the sensors from BMD, HAPS and NTRO systems. Manning of BMD and NTRO by IAF personnel makes it easier to integrate and operate these systems in a networked environment.

Future inductions of HPR, Mountain Radars and S-400 class of SAM systems with their embedded radars will significantly supplement the detection capability of ballistic and cruise missiles. S-400 class of missiles are also capable of intercepting ballistic missiles in endo-atmosphere regime and cruise missile, especially in 'self defence' mode. MRSAM radar may require some software change to detect ballistic missiles and engage them at closer ranges.

Deployment of Anti-ballistic missile system around NCR and other such Metropolitan cities would protect such VAs against only the ballistic missiles, whereas such VAs could also be attacked by other standoff PGMs, both air, and surface launched. It is, therefore, important to consider comprehensive protection of such VAs against all types of attacks. Other important VAs like military formations and other strategic targets like oil installations, nuclear forces and military industrial infrastructure are likely to be targeted by ballistic missiles. It would therefore be prudent to exploit additional capability of LRSAMs to provide integral AD protection including the missile defence. Net centricity can be well exploited to improve target detection and engagement capability of the Air and Missile Defence systems. No doubt, it would be impossible for any nation to protect all VA/VPs against all type of threats. There would be a need to consider VA protection priorities. Engagement of incoming threat must be quick and effective with prior approved SOPs and orders in place. There is no scope for lengthening the decision loop while engaging incoming known hostile threat. However, it would be important to share the filtered information with other agencies for their quicker follow up actions.

The nation must extract full capability of the expensive strategic assets that are generally available in limited numbers. While VLRTR types of sensors of NTRO are excellent assets to monitor specific activities, they are also capable assets to detect and provide better early warning against ballistic missile threat. 'Ownership' of such assets should not

impede in sharing crucial information that is available for other agencies to make use of. Net-centricity would enhance information sharing with relevant agencies in a secure and timely manner.

Space based assets will be crucial for enhancing space situational awareness and actionable intelligence, as further developments in sensor technology and secure satellite communications take place. Ballistic missile attack, monitoring hostile forces movement through Sigint sensors, geolocating targets, and mapping infrastructural developments and communications are some of the fields that can be best exploited by space based assets. It is important to share this valuable information with the dealing agencies in near real time. DSA would need to consider networking its Analysis Agency with MMS, IACCS and Service HQ operational Centers.

Rationalised Approach

Indigenous development of IACCS and MCC software has great advantage, as the source code is with Indian agencies, and it should be possible to modify the software as per operational requirements and reviewed Command and Control architecture. This will require close coordination between the agencies.

For providing comprehensive protection to NCR, and other designated strategic VAs, MCC, Space based data receiving Center and VLRTR radars should be integrated with IACCS. IACCS operation stations should be re-organised to have A&M NCR Director dealing with comprehensive protection of such VAs. With additional responsibility of Ballistic Missile defence, the IACCS should be renamed as Integrated Air and Space Command and Control System(IASCCS). 91N6E radar of S-400 SAM provides target data on all types of air threat including the ballistic missiles.[19] Inputs from BMD radars, S-400 target acquisition radar, NTRO VLRTR radars, Space satellites and HAPS (when

operational) should be fused to generate composite BM picture. The authority to engage all declared hostile targets should rest with ADCC through IACCS in its area of responsibility. Engagement process can be undertaken by MCC for anti-ballistic missiles and by Weapons Station of IACCS for other threats. Strategic Force Command (SFC) Operations Centre should receive filtered picture of the AMD and other air scenario for situational monitoring.

During peacetime, the control of the NTRO VLRTR type of sensors capable of ballistic missiles detection, should remain with NTRO. However, during crisis and heightened tension period, the control of the VLRTR should be exercised by the IAF through ADCC.

Air Force Network (AFNET) and Network for Spectrum (NFS) capabilities to service exchange of additional data should be examined and upgraded. The Data flow of the BMD and hypersonic attack vehicles should have priority over other data. If there is a constraint of data flow, dedicated network for BMD may be considered as a last resort.

IACCS should be the nodal agency to initiate ‘air raid alarm’ for civil administration to activate their plan.

To facilitate networking, all relevant sensors and shooters should have provision of overlaying software applications for RASP applications.

Likely Challenges

Organisationally, various sensors capable of BM detection are owned and maintained by different agencies. There would be difficulty faced in integrating these assets for operations. Directions from the ‘highest level’ should resolve this challenge, for ensuring maximum exploitation of these expensive national assets. Manning of NTRO and BMD assets by IAF personnel should facilitate integration and management of these assets smoothly.

Technically, networking and streamlined data flow would require further study to ascertain feasibility of streaming additional data with higher priority. Induction of the future sensors like HPR, HAPS and mountain radars should be networkable with IACCS. Full analysis of the network traffic, information priority and Command and Control software package, engagement algorithms would require major review and should be possible with active involvement of the operators and the scientists. Data fusion from sensors of different manufacturers would require interface and locally sourced algorithms which should be possible considering the mature status of the IACCS software.

Appointment of Committee of Experts dealing with the above mentioned challenges and clearly specified mandate should address the issues effectively.

Conclusion

Rapid developments in the fields of military technology have resulted in changes in operational concepts. Days of an attack aircraft overflying the target for weapon delivery are over. The fighters and bombers are now armed with standoff precision weapons capable of striking the targets from hundreds of kilometers. Ballistic missiles and cruise missiles have achieved credible delivery accuracy and they saturate and strain the defending forces without any fear of their own casualties. Recent conflicts indicate that future military engagements would involve significant employment of conventional Ballistic missiles and cruise missiles. Important VAs like NCR would require comprehensive AD protection as deployment of just the BMD would not protect NCR from other modes of aerial attack. The nations would require integrating all AD assets to ensure optimum and effective exploitation of the resources available. This would require effective and secure networking to provide fused data for employing the most suitable weapon in the shortest decision loop. Space based assets would provide valuable inputs in

detecting and engaging ballistic missiles and cruise missile. India has achieved success in developing an indigenous BMD system and its deployment to protect the NCR should have been approved. However, for comprehensive protection of such VAs, comprehensive air, and missile Defence is considered essential. The IAF has well established robust and resilient Integrated Air Command and Control System which can function as the C2 node for BMD and Air defence operations. S-400 SAM under induction has significant ballistic missile detection and interception capability. Data fusion from all assets capable of BM detection, including the sensors in space, would ensure comprehensive and wider BM defence capability. Organisational changes are required to exploit all assets of air and Missile Defence systems under one authority, for their optimum employment. Home developed software of BMD and IACCS can be best exploited to change the target engagement strategy and C2 architecture to match the operational imperatives. Time has come to surpass the organisational and technical impediments and be prepared for future war scenarios.

***Air Marshal Daljit Singh, PVSM, AVSM, VM (Retd),** is a former AOC-in-C, South Western Air Command and Assistant Chief of Air Staff (Air Defence) and Director General (Air Operations).

Endnotes

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