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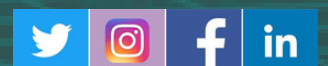
SEMINAR REPORT ON ROADMAP FOR THE FUTURE: TECHNOLOGY ENABLED SENSOR-DECISION-SHOOTER SUPERIORITY

ORGANIZED BY CENJOWS, DRDO & IMR

30 JUNE 2023

SEMINAR REPORT
ROADMAP FOR THE FUTURE:
TECHNOLOGY ENABLED
SENSOR-DECISION-SHOOTER SUPERIORITY

ORGANISED BY CENJOWS, DRDO & IMR
30 JUNE 2023

Rapporteured by

Aditya Acharya
Ankit Kumar
Anushka Gupta
Emmanuel Selva Royan
Neeti Rathi
Shreya Mamgain
Research Interns, CENJOWS

The **Centre for Joint Warfare Studies (CENJOWS)** and **Defence Research and Development Organisation (DRDO)** in partnership with **Indian Military Review (IMR)** organised a seminar on "Technology Enabled Sensor-Decision-Shooter Superiority," on 30 June 2022. The seminar was held at DRDO Bhawan, New Delhi.

The seminar featured distinguished speakers including serving senior officers and senior scientists from DRDO. A few industrialists from space and advanced computer based industries also participated.

INAUGURAL SESSION

In his welcome remarks **Lt Gen Sunil Srivastava, AVSM, VSM** (Retd), Director CENJOWS** thanked the speakers, panellists, participants and other serving and retired senior officers for being in attendance. He elaborated the theme of the seminar and stated that the war and conflict now entail exploitation of unprecedented unmanned vehicles and leverage commercial technologies.

Dr Samir V Kamat, Secretary Dept of Defence R&D & Chairman DRDO, delivered the inaugural address by thanking distinguished guests and panel present and reiterated the theme to emphasise on the multitude of high sensor technologies present in the world and that the future of battlefield will be of a Network Centric Warfare.

He mentioned that the real winners of the battlefield are those who can pass on the information from various sensors to decision takers to address the where and how questions. He said that this process helps in identifying and targeting, directing the most appropriate weapon to shoot.

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He hoped that this seminar is a good opportunity for the services and think tanks to sit together, brainstorm ideas that will result in an actionable roadmap.

Shri Sunil Kumar, Senior Technology Technical Director, Dassault Systemes, gave a talk on Virtual Twin Experience for Defence System Development and Operations.

He explained how the Virtual Twin (VT) experience model, which is a virtual model of a physical system which brings in learning and experiences taken from the real world processes to update the digital twin model. He suggested that if the VT model is employed on defence technologies, it could simplify the tedious process of setting it up, running quality checks and visualise the whole process in virtual reality for training and testing. He said there will be no need for complicated manuals as the instructions will be highlighted and visualised in augmented reality channels. The machine health report will also be constantly monitored and visualised by the model.

The Keynote Address was given by the Guest of Honour for the Seminar, Gen Anil Chauhan, PVSM, UYSM, AVSM, SM, VSM, Chief of Defence Staff (CDS):-

- He emphasised on the need of integrating and promoting jointness among the three services of Indian military forces. In addition, how technology, data and information are playing a crucial role in 21st Century Warfare, where results are decided within seconds or minutes, where space enables warfighting in land, air and water domains.

- He mentioned that technology-enabled sensor-decision-shooter is a subset of military-capability development. Technological development decides the course of warfare and vice versa. He focused on enhancing military capability effectively during the time of peace, crises and conflict.

- He asked for a whole-of nation approach to counter one-upmanship and to promote jointness and integration among tri services, holistic integration to be assisted by a clearly laid strategy.

- He said that War like the historic World Wars of the 20th century do not occur anymore, but today confrontation and contestation in the form of limited conflicts are at the forefront. Appropriate application of military assets and military force is critical to win the confrontation continuum.

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- The CDS observed that wars have several campaigns, a campaign has several battles and a battle consists of many engagements. In order to win a battle, one needs to win 80% of engagements, if 80% of battles are won, campaign is won and if campaigns are won, victory is ours.

- He put much significance on engagements, mentioning the importance of tactics, operations and procedures that produce decisive results in an engagement. He explained the salience of OODA (Observe, Orient, Decision and Action) cycle to enhance the efficacy of engagements.

- He said that technological sensors on the battlefield will provide accuracy, transparency of data and edge technology will provide the necessary information. Sensors for Navy, Army and Air Force should be linked.

- Orientation has to be multi-dimensional rather than uni-dimensional. It should focus on all areas at all times. Situational awareness should be high in modern warfare. Decision making is the most significant component in warfare and it can be manned, assisted by unmanned. Actions are led by combat and controllers while seeking assistance from unmanned platforms.

- Commenting on where the Indian Army stands currently, he said that in terms of network capability we are good, our forces are network centric, assisted by AI tools. IACCS and TRIGUN are used by the Air Force and Navy respectively. AKASH TEER of the Army will fuze with IACCS shortly. The Army uses battlefield surveillance and management systems. In terms of sensors, we have drones for border surveillance and NAVIC satellites for navigation. SBS-3 will be launched soon, with participation of private players. In the field of shooting capability, we have long range missiles, Brahmos, EW Platforms and AD Missiles.

- In order to enhance India's capabilities, he mentioned the need to improve stealth and hypersonic technologies, interweaved with AI. To increase communication and integration among all is vital.

Dr Subrata Rakshit, DS & DG (TM & SAM), DRDO ended the inaugural session with a Vote of Thanks to the CDS and the panelists present. He thanked CENJOWS team for jointly organising this seminar with DRDO and mentioned that this initiative is an

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opportunity for the services and think tanks to sit together and discuss critical issues. He further hoped that this seminar will be a brainstorming event to produce pragmatic outcomes.

SESSION 1 - STRATEGIC & MULTI-DOMAIN AWARENESS

The chair of the first session, Dr Subrata Rakshit opened the session stating that there is a growing focus on sensors and their capabilities, with significant growth in both the domains to be sensed and the technology used.

The increasing interest in sensor technology is crucial as it provides a wealth of data to the users.

The session aims to bring perspectives from scientists and the industry on what the Armed Forces are looking for and how the technologies developed can meet their requirements.

Key Takeaways from Talk by Smt Rose Abraham, Scientist F, LRDE on Multi-Static Counter Stealth Radars:-

- Stealth technology refers to a set of technologies that make it difficult to locate aerial targets.

- DRDO's Electronics and Radar Development Establishment (LRDE) is working on developing Multi-Static Radar Technology.

- Multi-Static Radar Technology can be understood through different components, including Multi-Static Surveillance Radars (Radar Emissions), Passive Coherent Location Radar (Broadcast Emissions), Passive Emitter Tracker (Onboard Emissions) and Integrated Multi-Static Surveillance System.

- The Integrated Multi-Static Surveillance System (MSS) is considered the most advanced form of Multi-Static Counter Stealth Radar System, as it combines the capabilities of PCLR, MSR and PET technologies.

Key Takeaways from Talk by Air Cmde Vivek Gupta, VM, Air Cmde Ops (IEW), Air HQ on the Need for Enhanced ISR (Intelligence, Surveillance and Reconnaissance) Capabilities for Future Battlespace:-

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- Battlespace transparency is a key pillar of Air Strategy.
- ISR is considered all-pervasive, continuous and domain-neutral, spanning multiple domains regardless of the type of air operations being executed.
- Different types of ISR include HUMINT, IMINT (Imagery Intelligence, Imagery Interpretation and Video Transmission), SIGINT (Signals Intelligence) encompassing ELINT (Electronic Intelligence) and COMINT (Communications Intelligence), MASINT (Measurement and Signature Intelligence), CYBER intelligence, GEOINT (Geospatial Intelligence) and OSINT (Open-Source Intelligence).
- Challenges associated with ISR include existing capacity gaps, high latency, and survivability in contested theatres.
- Recommended solutions for enhanced ISR capabilities include multi-function space-based assets, High Altitude Platform Systems (HAPS) such as with Air Balloons, pseudo-satellites, improved manned and unmanned airborne assets including MUM-T (Manned-Unmanned Teaming) and multi-function sensors.
- The Indian Air Force is committed to leveraging technology for ISR and has taken steps in this direction, including the development of an AI/ML-based application for ISR and multi-domain operations.

Key Takeaways from Talk by Col Harish Kumar, Col BSS, DG Information Systems, Army HQ on Automated ISR and Technology-Enabled Decision Making in the Military:-

- Automated ISR plays a crucial role in collecting data for decision making and targeting in military operations.
- Technology-enabled sensors and systems are instrumental in supporting decision making and planning processes.
- Project Sanjay is a battlefield surveillance system focused on sensor management and imagery modelling. It provides an integrated surveillance picture to commanders and staff at all levels. It integrates data from various sources, including sensors, satellites, UAVs and patrols, to track the movements of adversaries.
- Project Shakti, integrates and coordinates shooters of the Army, Projects Sanjay and Shakti are linked.
- Project Akash Teer is an automation initiative for Air Defence encompassing a range of new systems, with a focus on indigenous technologies. It involves advancements in ICT (Information and

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Communication Technology), data processing, computing and predictive analysis. The project aims to empower the AD units of the Indian Army with state-of-the-art capabilities for integrated operations and effective control of ground-based air defence weapon systems.

Key Takeaways from Talk by Capt (IN) Shankar Krishnamurti, Capt Network Centric Ops, Naval HQ on Space-Based Surveillance in the Maritime Domain:-

- ISR plays a crucial role in covering vast areas of the air, surface and underwater dimensions in the maritime domain.
- Surveillance in the maritime domain needs to be quick and dynamic due to its constantly changing nature.
- Space-based surveillance is linked with terrestrial surveillance, with a focus on specific areas.
- Data relay from satellites is an essential component of space surveillance.
- The network architecture for surveillance can be both centralized and decentralized, depending on the specific situational requirements.

Key Takeaways from Briefing by Shri Vaibhav Gupta, Director, MKU Ltd talk on the Role of AI, Communication, Computing and Wearable Sensors for Soldiers in Changing Battlefield Environments:-

- Modern warfare involves various capabilities and processes that enable soldiers to perform their roles effectively.
- The Department of Defence invests in various fields to develop effective and secure communication systems for soldiers.
- Computing plays a significant role in decoding and processing data in the battlefield environment.
- Real-time data transfer systems and body armour are essential for soldier's survival and effectiveness.
- The use of advanced optical systems, logistics and mine clearance technologies are crucial in modern warfare scenarios.

SESSION 2 – INFORMATION SHARING: NETWORKS AND COMMUNICATIONS

Ms Jeya Shanthi, Outstanding Scientist & Director SAG, DRDO chaired the second session for the day. She said that while the previous session focused on

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collecting information and intelligence, this session will look into the communication and sharing of Intelligence.

Key Takeaways from Talk by Brig Vijay Koyiyal, Brig PMO SURAJ (IW Sys & SP), Army HQ talk on Multi-Domain Operations and the Importance of Network and Communication:-

- Modern warfare encompasses both kinetic and non-kinetic forces and ICT-enabled warfare operates in multiple dimensions, including surface, air, water, human, space, sub-surface and cyber.
- Challenges in multi-domain operations include vulnerabilities due to increased reliance on wireless technology, resistance to hostile actions, contested space, tech constraints in command, control and communication (C3), and potential constraints in AI/ML due to common standards.
- The need for standards and joint communication network is emphasised for enhancing interoperability and synergy at the national and operational levels.
- The creation of a task force and a data visualisation dashboard is recommended for effective analysis and improvement of networking technology to ensure security.

Key Takeaways from Briefing by Shri LC Mangal, OS and Director, DEAL on Communication Technology for Joint Operations:-

- Situational awareness is crucial in network-centric operations and multi-channel datalinks enhance the communication network.
- Embedded IFF (Identification of Friend or Foe) in weapons, long-range network bands, robust and reliable signalling, seamless data synchronisation and adaptability of equipment are important requirements.
- Software approaches are essential for achieving interoperability and efforts for interoperability, waveform standardisation and security frameworks are being pursued globally.
- The importance of Indian Radio Software Architecture (IRSA) for Indian military operations was highlighted, as it provides a repository for information and is developed using indigenous products.
- Collaboration between users and DEAL has resulted in the development of various software-defined radio (SDR) products for tri-services,

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including satellite terminals, data links and products designed for hilly terrain.

- Next-generation communication systems require features such as stealth for combat aircraft, swap-optimised avionics, all-digital radio, satellite communication terminals, BLOS (Beyond Line of Sight) links for hilly regions, software-defined airborne communication systems, satellite-enabled military IoT and advancements in 5G/6G technology.

Key Takeaways from Talk by Col ADS Gill, Col Signals-7, Dte Gen of Signals, Army HQ on Communication and Networking for Multi-Domain Operations:-

- Integration and jointness between the Army, Navy, Air Force, and Space are crucial for optimising battlefield efficiency in multi-domain operations.
- Integrated decision-making requires seamless information sharing in a secure environment within a limited timeframe.
- Net-centric communications are essential and communication should be theatre-based, considering the specific operational environment.
- The desired end state is a federated architecture that facilitates data sharing, situational awareness, seamless network connectivity, wireless communication and services run from a centralised data centre.
- Four lines of effort were mentioned, emphasising transparency, mobility of user devices, seamless flow of information and data synchronisation to counter data silos.
- A data centre should function as a warehouse of data, providing data to all applications and serving as nerve centres for decision-making.
- Focus is placed on compatible and secure user devices, high-capability wireless systems, software encryption, zero-trust databases, centralised analytics, web-based service applications, API gateway, data security, warehousing and indigenous security solutions.
- Evaluation testing and capability assessment of communication systems were highlighted as important aspects.

Key Takeaways from Talk by Capt (IN) Sandeep Biswal, Capt NW & Space Ops, Naval HQ on Network Centric Communications and Way Ahead

Wireless transmission, ship-to-shore communications and tactical networks for communication at sea are vital capabilities for the success operations by of the Indian Navy.

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The technology IN uses has been upgraded from analog radars and manual Morse code to the use of digital broadcasting techniques, customised SATCOMS and systems with built-in security.

He highlighted the challenges in naval communications as follows:-

- Delay in the adoption of modern technologies.

- The ranges of the radars used.

- Performances of radios affected by the environmental conditions.

- Space constraints for antennas.

- High MTBF and Low MTTR.

- Availability of spectrum.

- SWAP Constraints.

He listed the following recommendations:-

- Need for cognitive radios, which are aware of the operations environment and with a low rate of interference and jamming.

- Need for the miniaturisation/low SWaP along with the integrated active antenna, modularity with plug and play functions, BLOS low latency SATCOMS and remote monitoring and diagnostics.

- Quantum communications for secured communications and intelligence gathering and analysis.

- Signatures and Bandwidth Management ensuring critical applications to remain undetected at the high seas.

- Avoid the 'Valley of Death' situation by increasing Research and Development, and increased collaboration between academia, industry and the users.

He emphasised layered architecture and modularity are key.

Presentation by Gp Capt Umesh P Nagrale, Gp Capt Ops, AFNET, Air HQ an IAF Perspective on Network Centric Communications

He presented his insights on AFNET. It is a terrestrial OFC network with multiple service providers ensuring 1+1+R with two layers of redundancy, the first being a captive radio network and the second being SATCOM, where much work and upgradations need to be done. A Captive 5G Network is under installation replacing the present 3G technologies.

The expectations from industry and academia are as follows:

- High throughput encryption with built-in Network Management System.

- High capacity, low latency satellite network.

- AI-based multi-sensor data integration with pattern recognition capability for threat evaluation and mitigation.

- Quantum safe crypto system.

- Deployed rugged IOT devices in the battlefield environment.

Towards the end, he posed a question: Are we ready for such advanced encryption which would be able to handle terabytes of data and which would be safe from disruptions created by quantum technologies?

Key Takeaways from Briefing on the session on Secure Networks and Communications by Mr S Naresh, Solutions Manager, Parasoft APAC:-

- He emphasised the criticality of securing networks and communications in modern military operations, highlighting the need for robust data links in challenging environments.
- Network architecture, data centres and cloud technologies were discussed as facilitators of information sharing in secure military communications.
- Emerging technologies such as Software Defined Radio (SDR), MESH networks and Mobile Ad-hoc Networks (MANET), including joint networks, are critical for their potential in enhancing communication capabilities.
- Integrated service and tri-service networks were highlighted as significant for effective military operations.

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- He discussed the utilisation of unmanned nodes and electronic warfare platforms to ensure secure communications.
- The future of military Internet of Things (IoT) with the introduction of 5G/6G technology was touched upon, emphasising its potential impact on communication systems.
- Advanced technology perspectives, including quantum communications and collaborative autonomous systems, were discussed, emphasising the importance of system interoperability and upgradability.
- Adopting an open systems approach and adhering to industry standards were emphasised for secure communications.
- Network and cloud security, as well as signature and bandwidth management, were highlighted as essential aspects of modern communication systems.

SESSION 3 – ANALYSIS, INTELLIGENCE & DECISION MAKING

The third session was chaired by **Ms Suma Varughese, DS and DG MED, CoS & CS (MCC)**. She stated that session will focus on the interpretation and making sense of the data and intelligence acquired through various process. The role of advanced technology in data interpretation and decision making will be the outcome of this session.

Key Takeaways from Talk by Mr Lakshminarasimhaiah DR, Scientist 'F', CAIR on Machine Decision:-

- AI should have a top-down approach, indicating the importance of strategic thinking and decision-making in AI systems.
- In the military context, AI can be categorised into deliberative/strategic and reactive/tactical approaches.
- Deliberative/Strategic AI involves longer decision-making processes and high-level decision-making.
- Reactive/Tactical AI involves shorter decision-making processes and fine-grained decisions.
- The concept of Machine Decision (AI) can be understood through the F2T2EA framework, which stands for Find, Fix, Track, Target, Engage and Assess. This framework represents the sequential steps involved in a military operation, where AI plays a role in decision-making.

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Key Takeaways from Talk by Wg Cdr RS Verma, Wg Cdr Ops AD (ASAN), Air HQ on the Shortening of the OODA Loop through Enhanced Situational Awareness:-

- The OODA Loop is a decision-making process used in dynamic and unpredictable environments.
- Situational Awareness plays a crucial role in shortening the OODA Loop by enhancing perception, comprehension and assessment of the situation.
- Strategies for shortening the OODA Loop through enhanced situational awareness include information fusion, communication and collaboration.
- Decision Support Systems (DSS) can benefit from AI/ML technologies to assist in the decision-making process.
- In the context of a Battle Management System, solutions such as automatic interception, threat evaluation, weapon assignment (TEWA) and weapon assignment choice to operators can contribute to shortening the OODA Loop.

Key Takeaways from Talk by Lt Col Abhinav Chaudhri, GSO1 Automation, MI Dte, Army HQ on AI-Based Data Fusion and Visualization in Military Operations:-

- Data fusion plays a crucial role in modern warfare by providing timely and accurate information for decision-making.
- AI-driven data fusion enables the processing and analysis of large amounts of data in real-time, empowering military commanders with up-to-date information.
- Challenges faced by organizations in data fusion include dealing with disparate data sources, lack of real-time alerts, unstructured data and the absence of event prediction and challenges in force deployment.
- Natural Language Processing (NLP) can be employed to analyse vast amounts of data and extract relevant intelligence.
- Key components and use cases of AI-based data fusion and visualization include intelligence integration and fusion, recognition of hostile objects and targets and enhanced situational awareness.

Key Takeaways from Talk by Capt (IN) TSV Ramana, Capt NI, Naval HQ on the Role of Technology in Intelligence Analysis and Decision Making:-

- The cycle of intelligence analysis and decision making involves collecting, interpreting, analysing and disseminating information.

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- Decisions should be considered at all stages of the intelligence process, not just at the end.

- Technology should be used as an aid in intelligence analysis and decision making.

- The information collected should be quantifiable and structured to enable better analysis.

- The ability to identify and assess capabilities is crucial in intelligence analysis.

- Predicting the thought process can enhance decision making.

- Collection requires sophisticated infrastructure and a group of experts.

- Human judgement plays a significant role in analysis, but technology can help combine multiple pathways of analysis and make sense of information.

- Currently, technology is primarily used for tactical purposes rather than strategic use.

- Dissemination of intelligence has traditionally been done in a push manner but should transition to a pull approach.

- In the push method, intelligence is actively pushed or delivered to the recipients. It involves a centralised approach where intelligence agencies or sources proactively send information to the intended recipients without waiting for a specific request.

- In the pull method, recipients actively request or pull intelligence based on their specific needs or interests. It relies on a decentralised approach, where recipients have the autonomy to seek the information they require.

Key Takeaways from Briefing by Shri Sarabjit Singh Madan, Principal Solution Architect, Red Hat on Red Hat's Services to Defence Industries and on Creating a Digital Backbone for Defence:-

- Key technologies for establishing a digital backbone in defence include container technology, AI and edge computing.

- Container technology was highlighted as an evolutionary approach that offers a more efficient way of packaging and deploying information.

- Red Hat emphasises the consolidation and application of AI and machine learning within defence systems.

- Edge computing is recognized as a crucial component for supporting military operations and providing services at the edge.

- Red Hat has worked with the Israel Defence Forces (IDF) in a project called MAMRAM, where they supported the IDF's central computing

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system unit to facilitate multiple edge services for internal customers across the organisation. Red Hat has collaborated with Lockheed Martin on a project involving the Stalker UAS (Unmanned Aerial System). They demonstrated how AI-enhanced sensing capabilities on the Stalker UAS can enhance Joint All-Domain Operations. The Stalker utilises onboard sensors and AI to adapt in real-time to a threat environment

Key Takeaways from Briefing by Shri Krishanu Acharya, CEO of Suhora - Space Analytics on Driving Operational Success through Multi-Sensor EO and Analysis:-

- Suhora-Space analytics offers services related to defence intelligence.
- The company provides high-resolution optical and SAR (Synthetic Aperture Radar) satellite images.
- They have access to over 26 satellites for SAR images and 8 satellites for earth thermal sensing.
- Suhora has access to ICEYE's new Dwell Mode, which allows SAR satellites to focus on a specific point on the ground for an extended collection time. This mode provides more detailed and comprehensive information about the imaging target.
- The company's services can be utilised for border monitoring and detection purposes.
- They also offer slope stability monitoring in hilly terrains, leveraging their multi-sensor EO (Earth Observation) and analysis capabilities.

SESSION 4 - PROMPT & MULTI-DOMAIN TARGETING

The last session for the day was chaired by **Air Marshal BR Krishna, PVSM, AVSM, SC (Retd)**, Former CISC. He mentioned that this session is the end stage of the OODA cycle, humorously. He further explained that this session will be the end result of collecting intelligence, analysing and deciding: The role of technology in prompt and multi-domain targeting.

Key Takeaways from Talk by Air Cmde A Bhatia, Air Cmde Ops (Wpns), Air HQ on Emerging Technologies for Multi Domain Ops in Future Conflicts:-

- He highlighted the emerging technologies available for multi domain operations which have potential to revolutionise warfare which can bring a paradigm shift. The three technologies he focussed on in his address were; C-UAS, Loitering Munitions and Hypersonic Weapon Systems.

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- First, C-UAS, he outlined that the next-gen UAS can be used in aerial delivery, combat and search and as swarms for massed effects. But the vulnerabilities of UAS are slow motion, susceptible to weather, easy RF visibility, reliance on GCS and communication links and dependency on positioning system.

- Loitering Munitions are UAS that have the ability to loiter over target area for extended periods and are portable. They can be utilised against land, sea and air targets.

- Hypersonic Weapon Systems have advantages of velocity, manoverability, non-ballistic flight path and warhead versatility.

- Towards the end of his presentation, he brought to audience's notice that the gaps in AD systems due to these emerging technologies need to be filled. There is a need to focus on C-UAS kinetic and non-kinetic capabilities, importance of passive AD system and synchronisation of disruptive technologies.

Key Takeaways from Talk by Maj Gen Ranjit Singh, Addl DG Arty (A), Artillery Dte, Army HQ:-

- Complete spectrum of Sensor-Decision-Shooter needs to be addressed for prompt targeting, which can only be done through technology.

- The future battlefield will be highly transparent and will be characterized by intense engagements, through synergized and orchestrated employment of multiple fire power resources, in a non - linear pattern, with engagements happening simultaneously at varying depths across the frontlines, over protracted periods of time. These engagements will witness employment of precision and highly lethal weapon systems in a normal or hybrid environment.

- Today, high levels of transparency during day, night and through bad weather conditions have emerged due to the developments in ground based sensors, aerial and space based sensors. We have drones, which may be tethered or otherwise; Remotely Piloted Aerial Systems, which may be runway independent or may be of medium or high altitude types with endurances varying from three to thirty hours; aircrafts and space based sensors with varying sensor payloads. All of these form part of the Sensors component in the battlefield.

- High levels of precision, non - linear application of fire and intense engagement capability has emerged on the battlefield due to the

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development of longer range guns, rockers and missiles, with precision and other specialist ammunition.

- There is a need to maximize the outcomes of each engagement and so the operations and engagements need to be focused on 'effects desired'. The need of the hour is not just to destroy a given number of platforms or a given number of enemy soldiers. Instead, the aim is to target those troop concentrations, those assets of infrastructure or those logistics installations, which if destroyed provide critically vital advantages to own forces vis-à-vis the enemy.

- The plethora of sensors deployed in the war zone generate inputs in huge volumes, in the form of videos and imageries, in real time. All of these inputs need sifting, sorting and analysing of detection, recognition and identification of critically important targets. This is a challenge which requires a combination of human as well as automated, software solutions, based on Artificial Intelligence and Machine Learning.

- Our adversaries have extensively developed the capabilities of sensing, decision making and shooting, including the Artificial Intelligence and Machine Learning capabilities. We need to counter these by developing our own capability to survive enemy strikes, capability to recuperate after a strike and thereafter be effective enough to execute own operational tasks, optimally.

- For prompt multi domain targeting, we need to have robust platforms armaments and sp sys which will be sustained throughout the conflict in all times where we operate.

- What Indian Armed Forces need in the future is indigenous and effective systems, which do not rely on global supply chains for critical components, which could be denied in times of emergency. The platforms need to be capable of operation in HAA above 15000 ft and upto minus 30 degree temperatures.

- We need ground based sensors with all - weather detection capability at ranges beyond 20 kms. Similarly, in aerial surveillance devices, we need compact, light - weight all weather capability with opto - electronic sensors having sub - meter resolution at ranges beyond 20 kms above ground level and endurances beyond 24 hrs, making it possible to cover larger areas. The capability of aircraft and space based sensors to provide inputs of remotest depth areas of the adversary are also significantly important and need to be developed. However, to meet varying tactical and operational requirements, there is a need for aerial surveillance equipment with shorter endurance and capabilities also.

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- There is a need for missiles covering ranges from 300 to 3000 kms. Such capabilities exist. Rockets are required which cater for ranges from 50 to 300 kms and Guns which meet tactical requirements of upto 50 kms. A very interesting development here is the advent of SD & LM, wherein, the surveillance and targeting loop is the shortest. We therefore need SD & LM of ranges upto 100 - 150 kms.

- There is a need for precision and guided ammunition of varying variety which can create the desired effects. The value of massed artillery engagements with improved conventional shells will always remain relevant to provide fire support for ground operations.

- Accurate navigation and target acquisition systems in terms of IRNSS or NAVIC are critical not only for the sensors, but also for targeting. This is a capability that we need to acquire as one of our top priorities, because it saves time, effort & resources in any engagement.

- The dominance of non-contact non-kinetic and non-contact kinetic warfare has demonstrated the need to develop niche technologies in Communication Systems, Electronic Warfare, Cyber and Intelligence domains. We need to adopt disruptive technologies like Artificial Intelligence, Machine Learning and 3D Printing to remain ahead of the adversary's sensing, decision making and targeting cycle.

- In a theaterised environment, we need to ensure tri- service sensor-shooter integration as part of the Theatre's OODA loop. While sensors like HALE RPAS, Tactical RWI RPAs, Mini RPAs, ILROS and ULRS etc can effectively cover the tactical and operational depth, the gap in strategic depth needs to be filled by other Services and agencies including space based surveillance assets. All of these need to be integrated with the shooters ranging from basic artillery to rockets and further onto missiles, through a seamless communication architecture, to effectively engage time sensitive targets.

Key Takeaways from the Lecture on the Perspective on Prompt and Multi-Domain Targeting by Capt (IN) Nitin Kapoor, Capt SR Gunnery, SR Dte, Naval HQ:-

- He emphasised the criticality of prompt and multi-domain targeting in contemporary military operations. Effective targeting is crucial for mission success in modern warfare scenarios.

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- Loitering and smart munitions were discussed as means to achieve superior targeting. These advanced munitions can loiter over target areas and make precise strikes, enhancing targeting capabilities.

- He highlighted the need for long-range precision systems. Long-range capabilities are essential for engaging targets across multiple domains and achieving accurate and effective strikes.

- The pivotal role of command and control (C2) guidance was emphasised. Efficient C2 systems enable effective coordination and control of assets, leading to improved targeting outcomes.

- He explored emerging military capabilities such as laser, directed energy weapons and rail guns. These advanced technologies have the potential to enhance targeting capabilities and provide new options for engagements.

- The significance of countering unmanned aerial systems (C-UAS), counter-rocket, artillery and mortar (C-RAM) and anti-radiation capabilities in modern warfare was discussed. These capabilities contribute to the effectiveness of targeting operations.

- The utilisation of hypersonic weapons and the Fractional Orbital Bombardment System (FOBS) for prompt and multi-domain targeting was explained. These high-speed and manoeuvrable systems offer unique advantages in engaging time-sensitive and heavily defended targets.

- Technological perspectives covered in the session included hypersonic technologies and materials, critical and rare earth materials/minerals and the integration of long-range and non-kinetic effects. These factors play a crucial role in shaping the future of targeting capabilities.

- The importance of incorporating Beyond Visual Range (BVR) technologies for achieving superior targeting was emphasised. BVR capabilities enable engagements beyond the line of sight, increasing the reach and effectiveness of targeting operations.

- Situational awareness and the integration of indigenous and foreign origin systems were highlighted as important considerations. A comprehensive understanding of the operational environment and the interoperability of diverse systems contribute to effective targeting.

Key Takeaways from Talk by Sh Ajith B Choudhary, Scientist 'G' Project Director Akash & Programme Leader - HCM, DRDL on Hypersonic Weapons and Technology Challenges:-

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- There is an active battlefield zone ranging from 50 km to 500 km, which is considered a multi-domain field. Future weapons are expected to have ranges from 500 km to 2000 km, enabling operations across multiple domains.

- Hypersonic weapons were discussed, which can be categorized into two types: glide hypersonic weapons and cruise hypersonic weapons. Glide weapons refer to ballistic missiles with thermal coverings, while cruise weapons are derogatory in nature.

- Several countries, including the US, Russia, China, India, France, Germany, Japan and Australia, are at advanced stages of developing hypersonic missile programmes. This highlights the global interest and significance of hypersonic technology.

- The challenges in developing hypersonic weapons were outlined. These challenges include the need for effective fuel with high reactivity, managing thermal temperatures, ensuring a high emissivity body and addressing other technological hurdles associated with hypersonic flight.

- The speaker mentioned the Missile Multi-Disciplinary Organisation (MDO) as a future system with various capabilities in a country. This indicates the importance of coordinated efforts and interdisciplinary approaches in developing and utilising missile technologies.

Dr N Ranjana, Director, DSTA, DRDO summarised the key takeovers of the event, where she discussed the technological outcomes of the event. She mentioned that DRDO and CENJOWS had identified the sub-themes with great diligence.

She said that the seminar successfully covered over 70% of the sub-themes of the theme and the speakers provided their industry view, recommendations and expert analysis of the issues. She mentioned this seminar aided in bringing the whole kill chain process under a unifying umbrella.

Lt Gen Sunil Srivastava, AVSM, VSM (Retd), Director CENJOWS** ended the seminar with a vote of thanks to the DRDO, CENJOWS and IMR team for successfully organising the event. He thanked and congratulated all the speakers for presenting their valuable insights.

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