CENTRE FOR JOINT WARFARE STUDIES

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LATEST TECHNOLOGIES IN NIGHT VISION AND ELECTRO-OPTICS, CHALLENGES AND RECOMMENDATIONS FOR INDIAN ARMED FORCES

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Introduction

1. The growing need for national security and surveillance during both day and night, adverse weather and limited visibility conditions has led to an increased demand of Night Vision Devices (NVDs). NVD is an optoelectronic device that produces images in poor lighting conditions by conversion of both visible light and near-infrared light to visible light. NVDs and EO (Electro-optics) devices are constructed from three main blocks: optical objective, picture intensifier tube and ocular eyepiece. There are essentially two types of NVDs/ EO devices i.e. Infrared imaging systems and Thermal imaging systems. NVDs and EO devices call for requisite technical capability, indigenous capacity and tactical and operational usage. These devices have to be user friendly, lightweight and using less power so that the soldier remains agile. The combatants anta variety of devices but interoperability has to be the focus, be it sea, air or in the land domain.

2. The article covers the Latest Technologies in Night Vision and Electro-Optics in India and especially for Indian Armed Forces, the challenges and makes certain recommendations.

Latest Technologies in Night Vision and Electro-Optics in India

3. Requirement of the armed forces is improved ranges in various atmospheric conditions, recognition ranges of more than 40 Km, large Field of View (FOV), reduction in size, weight, power and cost, use of multiple bands –Short Wave Infra Red(SWIR), Medium Wave Infra Red (MWIR), Long Wave Infra Red (LWIR), data and image fusion, use of spectral information for better target discrimination, with multi spectral and hyper spectral technologies, large staring arrays, faster frame rates and higher operating temperature. 3rd Gen detectors are available and the element size ranges from 30 microns to 10 microns, which provides for high resolution systems and longer ranges. The latest available technologies are covered in the subsequent paragraphs.

4. **Armoured Fighting Vehicles (AFV)**.

(a) **Night Enablement of Commander (Cdr)**. In T-72 and T-90 tanks and BMPs, the commander uses the II (Image Intensifier) Tube based sight for recognition. The range is 3 Km by day and 700 m at night. Form-fit configuration has been developed by DRDO in which cdrs can see 3-4 Km at night. Integral eye safe LRF (Laser Range Finder) has also been incorporated.

(b) **LWIR Gunner's Thermal Imager (TI) for T-90 Tank**. Sighting system has been upgraded and the trials have been completed and it is under GS (General Staff) evaluation. The development of 3rd Gen T2SL (Type Two Super Lattice) detector for T-90 tank was done in collaboration with IMOD Israel.

(c) **Firing Capability in Commander T-90 Sight**. Inclusion of LRF was difficult to incorporate in the small space; hence, a common channel optical design was used for the existing day sight and LRF.

(d) **Detector of LWIR T2SL with TI**. This equipment has been developed between DRDO and IMOD Israel. LWIR T2SL is an alternative to LWIR MCT (Mercury Cadmium Telluride) detector having better uniformity and yield, leading to realisation of cost effective LWIR Thermal camera. T2SL technology can be tuned to work in SWIR/ MWIR and LWIR band.

(e) **Advanced Driver Night Sight (DNS)**. It incorporates an image fusion of TI and the day camera which enables tank driver (dvr) to drive the tank in dark using TI and also view beacon/ LED/ vehicle lights in the same fused image. It has a FOV of 45 x 34 degree.

(f) **Star: See Through Armour**. On the AFV, the cdr will be able to see at night a complete real time view i.e. 360 degree and the dvr will be able to see 100 degrees. The system will give a cdr complete orientation and situational awareness. It utilises Augmented Reality (AR).

5. **Infantry/ Artillery**.

(a) **HHTI (Hand Held Thermal Imager) with LRF**. It has five sensors TI, LRF, CCD (Charge Coupled Device), GPS (Global Positioning System) and DMC (Digital Magnetic Compass). It uses the spectral band of 3-5 micron, with detector 320 x 256 with 20 microns, having a range of 2 kms for human beings and 3 kmsfor tanks. It has a weight of 3.5 Kg with battery.

(b) **Weaponisation of HHTI**. For integration of HHTI with LMG (Light Machine Gun)/ MMG (Medium Machine Gun), a project was taken up by IRDE (Instruments Research and Development Establishment). It is a remotely operated system. It requires only one soldier who aims and fires using observation and engagement at a protected location.

(c) **Multi Spectral Surveillance System (MSS)**. The main features include imaging during day and night, day camera, SWIR and MWIR combined observation, eye safe laser. It is portable, light weight and tripod mounted. It uses a wavelength of 0.4-0.7 micron with FOV of 57.8-1.7 degree, having 36x optical zoom and ranges of 8 km for trees and houses.

(d) **Enhanced Situational Awareness**. A soldier has a two/ four tube binocular and fusion system at 40 degree FOV or 100 degree FOV. There are three modes i.e. II, TI fusion and TI fusion with Thermal Weapon Sight (TWS) overlay. It uses AR for target classification (between human, vehicle etc) and has compass readings displayed to assist in orientation. Then the image can be sent back to his cdr and the soldier can shoot at the target. With a two-tube binocular it will weigh 500gm and with four-tube binocular, it will weigh 900 gms.

(e) **Command and Control Framework – SPIDER.** Intrusion Detection System integrates EO and multiple sensors i.e radar, laser, Unattended Ground Sensor (UGS), perimeter intrusion fibre etc., as part of command and control using indigenous framework. It can be

centrally managed or a user at the edge, managing his local space, with the video streaming to a central command and control. The system integrates or using the data from other sensors that it has an access to, gives a common operating picture to the higher authorities. An example is the Perimeter Security Solution, which has a compact command and control system. As part of this system, a UAV (Unmanned Aerial Vehicle)/ UGV (Unmanned Ground Vehicle) can be launched on any intrusion, which will then observe and relay the input to the system.

(f) **Remote Control Weapon Station (RCWS)**. A 7.62mm MMG, developed indigenously with key features, which include an integrated bore sight with a day and night camera and can be electrically operated for 360-degree Azimuth and -10 to +65 degree elevation control. It has a remotely operated console along with the joystick and fire control switch. It is scalable to Heavy Machine Gun (HMG) application with 12.7mm gun. Applications include stand-alone unit/ on a vehicle platform/ for Anti Drone Systems or on a UGVs.

(g) **Uncooled TI Based Multi-Sensor System**. TASL (Tata Advanced System Limited) has indigenously designed, developed and manufactured the system, which is useful for short to mid-range observation upto 3-4 kms. It consists of latest Gen sensors in a single rugged housing. It includes Uncooled TI Camera, GPS, LRF and DMC. The system can be hand held/ tripod mounted or Pan Tilt Mounted.

(h) **Modular Long Range Surveillance Platforms (RAJAK ULR-25 & ULR-50)**. The features include day camera, TI, LRF, GPS, DMC in a single package. It is easy to deploy and has 25 kms and 50 kms range, large display, requires minimal user training and has power autonomy for operating in cold weather (24 Hr).

6. **Common for All Services**.

(a) **Megapixel Camera**. The main features include wider FoV (Field of View) coverage with very high spatial resolution, longer ranges, digital zoom with greater detail without image degradation and having an improved situational awareness. The application includes UAV, aerostats, naval applications etc.

(b) **Broad Band Detector (1-5.4 micron)**. It features a SWIR sensor which results in large surveillance range (atmospheric transmission) in the day and in night gives improved resolution. An IR detector with smart on pixel laser detection mechanism is beneficial

for the target identification process and IR system capable of measuring the range to the target will have quicker target positioning on the battlefield.

(c) **2D LRF**. A TI system with advance LRF abilities and no requirement for bore-sighting of LRF and IR Detector. The laser spot is visible, hence the system can aim the laser at different targets and get the distance map. Advantages include improved identification and 2D range mapping of the target.

(d) **High Operating Temperature (HOT) IR Detector Based EO System**. HOT detectors enable an improved range of solutions including faster cool-down time and mission readiness, longer mission times and higher cooler reliability. IR detector operates at temperature of 150 K. It is portable, light weight and has better resolution and longer ranges as compared to previous generation systems. The applications include surveillance and acquisition, target ranging, own and target geo-location etc.

(e) **Trends in Uncooled Detector Technology**. These include Megapixel array format, Noise Equivalent Temperature Difference (NETD) of 10-20 mk (milli-kelvin) and with the frame rate 60-400 Hz with the range of 1-1.5 Km. Applications include defence against airborne threats, target acquisition and mini/ micro UAVs.

(f) **Aviator Night Vision Goggle for Airborne Platforms**. The system features a high-resolution II for sharper image compatible with all helmets, automatic brightness control, auto-gated and a low distortion output optics etc.

(g) **Infrared Panoramic Surveillance with Powerful Automatic Detection and Tracking i.e. SPYNEL Cameras with CYCLOPE Software System**. The system addresses the threat over a wide area to include UAVs, drones, parachutes, vehicles, boats, tanks, aircraft, missiles, human etc. It is a passive system having high resolution panoramic thermal imaging, automatic real-time video recording with CYCLOPE fully integrated intrusion detection software. The main function of CYCLOPE software is automatic classification of threats according to multiple conditions (dimensions, trend, intensity, speed etc.) and automatic alarms to trigger specific actions. The advantage includes ease of operation and ease of setting up and resistance to electronic interference. SPYNEL systems is light weight (1.8kg), low power consumer, uncooled IR imager integrating LWIR detector with two modes of operation – panoramic mode and sector scanning mode.

(h) **Stabilized EO Solutions**. Gyrostabilised cooled EO systems have been indigenously developed for Naval vessels. They include integrated sensors i.e. day, TI and LRF in a single housing, wide FOV, remotely operated and 15" operator console with joystick. Applications include sight for vehicle platform, mast mounting and EO for Anti Drone applications.

Challenges in the Manufacture of NVDs, Sights and EO Equipment in India

7. Basic Building blocks of NVD and EO equipment comprise Optics (Thermal engine which is Cooled or Uncooled), Electronics, Software and Systems Packaging. These optics generally operate in 2 to 5 micrometers and 8 to 12 micrometers bands. The challenges include: -

(a) **Good Quality of Coating Material**. There are challenges in producing good quality of coating material and the processes involved in the coating. It has to be imported.

(b) **Coating Processes and the Validation of the Working Processes**. The coating processes and the validation of the working processes is a challenge.

(c) **Packaging of Optics**. Skilled manpower for packaging of optics remains in short supply.

(d) **Detector Technology**. Detector technology is not available in India for making Thermal Engines for TI i.e. SWIR, MWIR and LWIR. Hence, the Atmanirbharta focus is to make semiconductors indigenously. Presently, we are getting the image from all these detectors individually i.e. SWIR image, MWIR image and LWIR image and industry/ DPSUs are harmonising the image from the diverse data. It is not a single integrated technology, and hence the equipment becomes bulky, and image is not of good quality.

(e) **High End Software**. Video engine and display is available in India but the high-end software is not available.

(f) **System's Strategy**. We cannot have very bulky systems, which consume a lot of space. Hence, the requirement is of miniaturization and system packaging.

Challenges for Indian Armed Forces

8. For Indian Armed Forces the challenges include:-

(a) **Image Intensifier**. Lack of effectiveness at ranges beyond 300m, ineffectiveness in bright conditions, complete darkness and in inclement weather conditions.

(b) **TI**. A fragile assembly, high battery consumption, reduced resolution and increased fatigue to the operator.

(c) **Aviation (Avn)**. The restriction factor in Avn for night enabled ops is flight safety constraints, pilot fatigue, equipment constraints and operational environment.

(d) **Limits of FoV**. There are limits of FoV, i.e. loss of peripheral view, which reduces the situational awareness, the depth perception and distance estimation.

(e) **Sensors**. IR sensor, accuracy and identification basically for SAR sensor, and aligning to the aircraft system would be a key challenge to mitigate.

(f) **Human Factor**. The human factor for undertaking night operations includes natural fatigue, hence automated systems are needed.

(g) **Situational Awareness**. Mainly for Air Force, ground support for situational awareness is another challenge.

(h) **Limitations of Radar**. It includes weight and size of radar, susceptibility to ECM, dependence on RCS (Radar Cross Section) and range of target and most importantly, active emission makes the technology extremely vulnerable in the operational environment. Radars are also susceptible to multiple errors, making accurate targeting at close ranges difficult.

(j) **Defence Against Aircraft**. An aircraft is a fast-moving platform which requires faster processing and analysis. It can launch a precision strike from standoff ranges, which is a challenge. These challenges are enhanced in naval environments when flying from a moving deck.

Recommendations

9. Salient recommendations are as follows:-

(a) We need to activate the well-known collaborative triangle of government, industry and academia so that indigenous development of night vision technology can be synergised. This has the advantage of reducing the cost of development by synergising brains and resources for lateral developments of new technologies.

(b) Certain gaps in capabilities should be addressed in a synergised manner with participation of DRDO and private industry together, especially in areas of multi spectral fusion, higher FOMs (Field of Magnification) (2000+), miniaturisation and autonomous functioning, long battery life and integration with command-and-control elements using Artificial Intelligence (AI).

(c) The need to encourage private vendors and providing access to in-service equipment to hand hold the industry is essential for finding innovative solutions under Atmanirbharta. There is a need for infusion of investment and technology.

(d) Indigenisation development and absorption of critical technologies by Industry/ DPSUs/ DRDO is the key in the long term. But in the short term, we need to collaborate with foreign partners, either by the DRDO/DPSU/ private vendor, to acquire Gen 3 NVDs, so that we can leapfrog the technology gap.

(e) NVDs should not be looked in isolation and should be seen comprehensively as a night fighting system. Night vision should be integrated with many other systems, be it navigation systems and combat systems etc. Individual helmets or rifles should be integrated with communication systems, weapons and sensors and not just for one platform or individual; through networks, which can transmit images and information across the entire combat unit.

(f) Indian Armed Forces need to provide the comprehensive staff requirements to the technology developers.

(g) Greater synergy between all the stake holders and the user is required to provide the right equipment to the Armed Forces. Formulation of QRs based on the latest technology will allow faster growth and also assist the forces in acquiring world class equipment. The users essentially desire modularity, replaceability, repairability and upgradability with reduced SWaP-C (Size, Weight and Power, Cost).

(h) Integrated visual augmented reality systems, developed by the industry is the need of the hour.

(j) Industry needs to find innovative solutions for use of technology to overcome limitations of weather especially fog and foliage.

(k) The detector technology has to be indigenous. NVDs, LRF and counter UAVs systems are the need of the hour, hence technology investment should be enhanced to cover multiple areas.

Conclusion

10. Disruptive technologies have blurred the line between day and night and there is a paradigm shift towards increased lethality, non-linearity and 24x7, all weather operations. Finding, fixing and finishing is the essence of war fighting. Hence, winning is all about long range detection and precision effects, with on-board sensors. At the Tri service level, interoperability is the key. In Atmanirbharta, the main focus is to produce semiconductor chips. DPSUs/ DRDO must stay focused on knowhow to absorb technology and methods to enhance it. Private industry must come up with the capability to build capacity through innovation and imbibing the best practices with the industry partners.

CERTIFICATE

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