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INDIAN DEFENCE INDUSTRY: OPPORTUNITIES ACROSS VERTICALS

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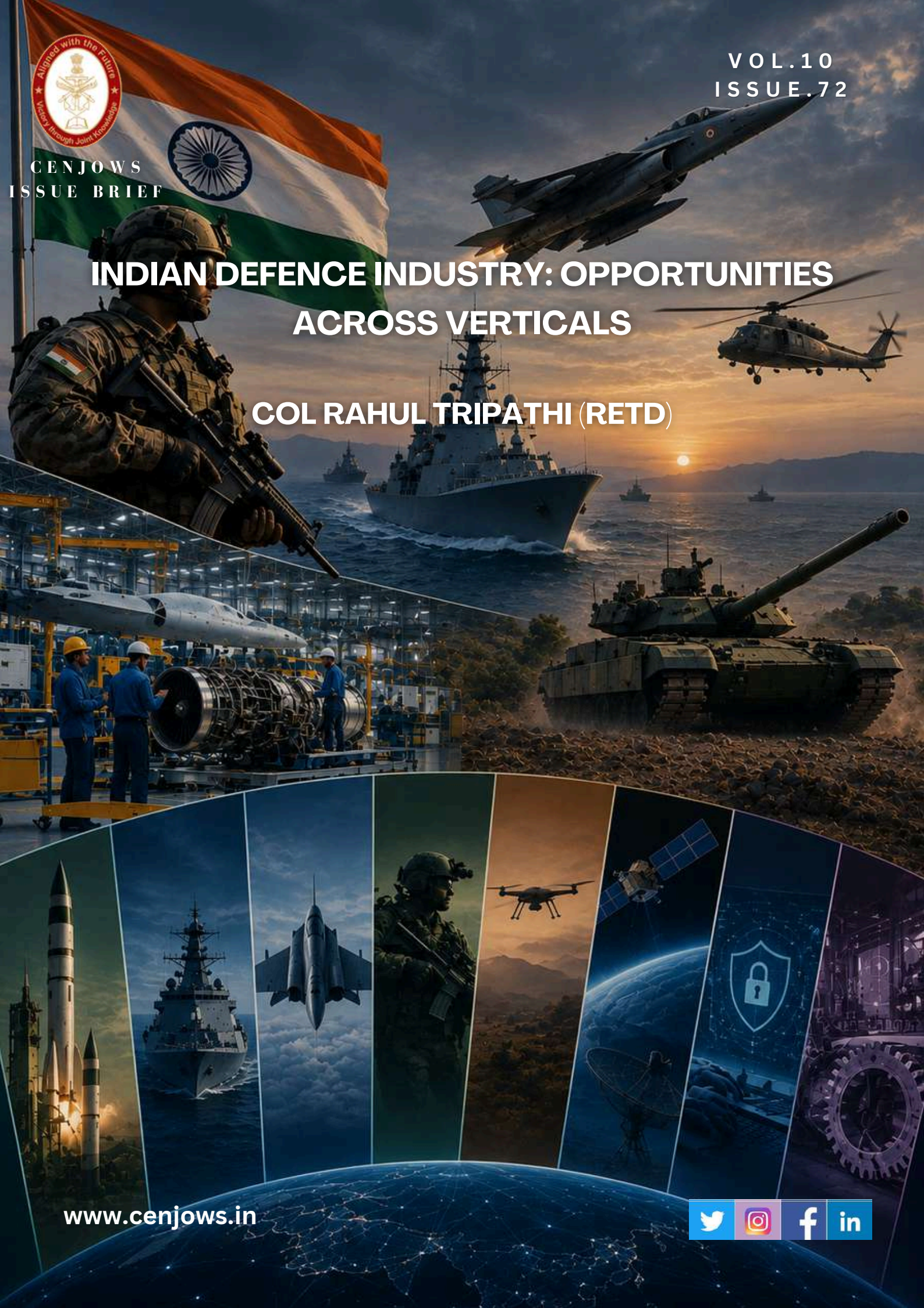

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ABOUT US

CENJOWS was raised in 2007 as an independent think tank, registered under the Societies Registration Act, 1860. This aims to promote Jointness as a synergistic enabler for the growth of Comprehensive National Power and provide alternatives in all dimensions of its applications through focused research and debate.

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Indian Defence Industry: Opportunities Across Verticals

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Introduction

Arthashastra says the seven constituents of a nation are the king, the minister, the country, the fort, the treasury, the army, and the ally. The security of a nation, however, is a complex balance between internal stability, m aterial readiness, and strategic external relations. This balance can be achieved by a strong king (central power) who prevents internal dissent and anarchy, ensures a strong treasury through which material and physical readiness can be guaranteed and carries out extensive geopolitical engagements to prevent external aggression.[1] An interesting White paper came out from European Union "European Defence – Readiness 2030", in short it tells us that Europe has been lagging behind in its defence and will need to massively use finances to get the capacities for defence production up by many times.[2] This is surprising, as Europe boasts of the best defence industrial complex after the USA.

In comparison, India has post-independence tried to have a robust defence production but till as late as 2018 / 19 we were dependent on foreign technology, foreign platforms (tanks, ships and aircrafts) and subsequent maintenance requirements. Very little was

being produced indigenously, and most of it was through licence production without Intellectual Property Rights mainly by the various Public Sector Undertakings, till a slew of reforms took place in 2019 and onwards.

Historically, the Indian defence verticals, i.e., land systems, air systems and sea systems, were predominantly produced by public sector undertakings (PSU). They did do their best, considering the technological gaps that existed due to deliberate policies by some nations to keep high technology away from India.

India has vied for strategic autonomy; the same, however, cannot be achieved till such time that we produce all our defence needs ourselves. Keeping this in mind, this article will try to bring out all the verticals of the Indian defence industry and how they are supported by Tier 1 and Tier 2 suppliers. It will also bring information towards where the Indian defence industry is headed and whether an innovator, an investor, a Micro, Small, and Medium Enterprises (MSME) etc can pitch in to make it grow even faster and bigger.

Air Systems

- **Military Aircraft (fighters, transport, helicopters).** There is an ecosystem which is building at an extremely fast pace all types of aircraft and helicopters. Firstly, there are the service aircraft of the Indian Airforce, over 2000 of various types of aircraft (trainers, fighters and transport) and helicopters, these have different origins and make for a very complex mosaic.[3] Most of them have decades of life that is left, and this gives reasons for upgradation of avionics, weapon systems, RADAR systems, etc. Then there are aircraft and helicopters that are in the pipeline to replace the current ones in use. It is here that the private players are being sought to speed up the R&D for making most of these air systems platforms in India. A very live example is the fact that for the indigenous 6th gen aircraft, i.e., for the Advanced Medium Combat Aircraft (AMCA) project, the Request for Proposal has been given only to three private companies. It may well be noted that all major aircraft manufacturing companies in the world (Boeing, Embraer, Airbus etc) now have their offices in India and through JVs or MoUs are entering the Indian aircraft manufacturing domain not only for the military aircrafts and helicopters but also for the civilian ones.

- **Airborne Equipment and Ground Support Equipment.** For all flying Aircrafts, Helicopters and UAVs there are a host of equipment that is onboard them, some are common like the Solid-State Flight Data Recorders (SSFDR) the Compass or the Global Positioning System (GPS). Others are unique to each, making them complete their tasks, like laser designators in fighter aircrafts or winches in helicopters. Then there are some for safety, like the tail rotor vibration warning systems in helicopters and warning indicators of all kinds. These form a subset of equipment / line replaceable units (LRUs) that fly on the aircraft and are called Airborne Equipment.[4] There is another set of equipment that is needed on the ground (airports and helipads) known as ground support equipment, which assists in flying operations.[5] These range from small ladders, to cranes, to refuelling vehicles and pumps, firefighting trucks etc. Then there is ground support equipment in the Air Traffic Control Tower, radars, optical instruments etc. Both the airborne equipment and ground support equipment need to pass stringent tests to qualify for service. It will be well taken that most of the ground support equipment and some of the airborne equipment have dual roles and can be used for military as well as civilian requirements. All these airborne and ground support equipment also requires testing and certifying benches of various kinds and workshops for maintenance. If one has to look at the business potential of these, it is worth understanding the government of India's Project Udan.[6]

Sea Systems

- **Ships.** There are surface ships, and there are underwater submarines, with this as a broad classification, let us look into the Sea Systems in total. From a two-meter dingy survival floating craft to small boats and large destroyers to Aircraft Carriers, this segment comprises all that remains above water. Another major aspect is that most ships have a permanent human aboard crew, this makes these systems even more complex, keeping the requirement of the humans who will need to stay for days if not months on these ships.[7] Within this segment there is shipborne equipment that assists the ship to move, communicate and carry out its tasks. These are:

- **Combat & Weapon Systems.** Comprising guns, missiles, torpedoes, depth charges, and Close in Weapon Systems (CIWS).
- **Sensor & Surveillance Systems**. Radars, Sonar Suites, electro-optical sensors and electronic warfare equipment.
- **Propulsion & Marine Engineering Systems**. While mostly below the deck, without these ships, they will not be able to move.
- **Airborne Support Systems.** Similar to those in an airport for the Aircraft Carrier and in all ships for Helicopter Operations.
- **Command, Control & Communications Systems**. Which would assist the control element of the ship to carry out their specific tasks by controlling all the systems mentioned above.
- **Survival Systems**. To include specialised firefighting equipment, life rafts, etc.

- **Submarines.** All the above systems are also found in the submarines, albeit of a fundamentally different nature for sub surface requirements. Besides these, the following additional systems are required:
  - **Diving and Surfacing Systems.** Ballast tanks, and compressed air systems for buoyancy control to ensure diving and surfacing.
  - **Atmosphere Control Systems.** Due to highly confined spaces, strict atmosphere management is required to make the limited habitability comfortable.
  - **Life-Support Systems**. Such as oxygen generation, CO_2 scrubbing, air conditioning, humidity control, etc.

- **Port/Shore Equipment.** When the ships come to port, they are required to be replenished and maintained. This may take from a few days to months if serious repairs or refitting are to be carried out. All this requires different kinds of shore equipment, from cranes to fuel pumps and pipelines, generators, etc.

- **Shipyards.** These build various naval ships and submarines, and while the work involves months of work, it's the place where major systems spoken about are built into ships. These require specialised equipment and thousands of

different kinds of Military-Grade LRUs, etc. These form a different segment within the sea systems that are important for a modern Navy.

Land Systems

- **Weapons.** These range from pistols to big artillery guns and, for ease of understanding, are categorised into Small Caliber, Medium Caliber and Heavy Caliber Weapons.[8]
    - Small Caliber Military weapons are usually from 9mm to 12.7 mm. Within this range you have pistols, machine pistols, sub-machine guns, rifles, sniper rifles and crew served machine guns.
    - The Medium Caliber weapons cover the range between 12.7 mm to 50 mm, and include Heavy Machine Guns, Infantry Tactical Mortars, Grenade Launchers, anti-aircraft guns etc.
    - Heavy Caliber covers all other weapon systems, from mortars, artillery guns, Recoilless Rocket Launchers of all kinds.
    - Rockets and missiles are also used by the land forces and today form a very niche and increasingly potent weapon system with extremely long ranges and pin point accuracy.

- **Vehicles.** There are three distinct vehicle categories that are used by land systems, the armoured vehicles, the logistic vehicles and the specialist vehicles.[9]
    - Armoured Vehicles comprise of the Tanks, the Infantry Combat Vehicles (ICV) and the various variants based on common tank / ICV chassis for other operational roles like Self Propelled Artillery, Anti-Aircraft Weapon Carriers, Mortar Carriers etc.
    - Logistics Vehicles would mean all light, medium and heavy load carriers, classified as four-to-30-man carriers or one-to-20-ton load carriers.
    - Specialist vehicles are those required in lesser numbers but highly important for the war effort. These would mean the Command-and-Control vehicles, the Communication Vehicles, Bridge Layers, the anti-mine trawls, bull dozers of all kinds, cranes for refit and recovery of military equipment, kitchen lorries etc.

- **Radio Frequency Transmitting Systems**. They are broadly of two kinds: one that provides for its own communication radio systems and disruption of the enemy's communication Electronic Warfare Systems and the radars of all kinds.
    - Communication Systems would comprise of Tactical radios (HF, VHF, UHF) to Battlefield Communication Networks, Command, Control, Communications, Computers, Intelligence (C4I) Systems, Electronic Data Transmission Systems and Sensor & Weapon Integration Links. Further within this category would be all Electronic Warfare Systems that disrupt the enemy's communication like spectrum monitoring systems, jammers, etc.

    - RADARS in the land systems are required for a multitude of tasks, from battlefield ground surveillance to weapon locating. Then there is the traditional role of Air Defence and the very important Fire Control Radars which direct their own fire against enemy targets of different kinds.

Unmanned Vehicles (UXVs)

The modern war has seen a shift towards Unmanned Land, Sea, and Air systems. The two conflicts in Nagorno-Karabakh (1999) and the current Ukraine war have made every country look deeply into unmanned systems. These are of various kinds and used for various tasks. Mainly of four kinds Unmanned Ground Vehicles (UGVs), the Unmanned Aerial Vehicles (UAVs), the Unmanned Surface Vehicles USVs (sea surface) and the Unmanned Underwater Vehicles UUVs (subsurface).[10]

- **Unmanned Land Systems.** The main focus of the Unmanned Ground Vehicles (UGVs) is to reduce the physical burden on the soldier and reduce risks by operating in the high-risk zones. UGVs are used for direct combat armed with suitable weapons, engaging enemy tanks, infantry or fortifications. Then, there are logistic UGVs which carry out tactical resupply of ammunition, heavy gears, rations etc over terrain on either wheels or tracks, these may also be used for Casualty Evacuation from active fire zones to reduce risk of lives. We have already seen the Explosive Ordnance Disposal UGVs in action, removing IEDs

being worked from a distance. UGVs are also used with ISR devices for carrying out reconnaissance in built up areas as well as terrain of all kinds.

- **Unmanned Air Systems.** UAVs, or drones as they are known, are the flavour of all armies today. They provide vertical dominance, long distance surveillance and precision strike capabilities. As per their tasks, they can be divided into combat UAVs with precision strike capabilities, heavier U-CAVs working tandem with own fighter aircrafts and loiter munitions also termed Kamikaze UAVs which destroy by directly attacking the enemy target. ISR UAVs loiter at different altitudes based on their categories (MALE HALE, etc) and provide constant intelligence through surveillance of the area under reconnaissance. Then there are Electronic Warfare Drones which degrade enemy's RF transmissions by jamming communication systems and radars. A lot of work is going on for logistic UAVs, especially for the high altitudes.

- **Unmanned Sea Systems.** Like the air and land systems, these are being developed to carry out combat roles, ISR roles and logistics roles. However, they have a specialised category of Under Water Unmanned Systems. These are from a few Kg to hundreds of tonnes. They reduce the risk of human life under-water, and are also are easier to manufacture compared to conventional submarines, as pressurisation for human sustenance is not required. Both surface and sub surface Unmanned Sea Systems have proven their worth in the Ukraine war and are now being developed for longer ranges and larger roles.

Counter Unmanned Systems

Since the unmanned Air, Land, Sea, and Sub surface vehicles have become highly potent, there is a need to counter these too. The traditional Air Defence Systems comprising radars and Air Defence weapons were developed for large, fast-moving targets. They do not cater to defeat this increasing threat of small, long-range vectors that move at tree top height, can rapidly change directions and not be seen in most radars. This segment needs to be understood as to how it works.

Working of C-UAS

There are three steps to counter an unmanned system, the first is detection, the second is tracking and the third is neutralisation. For a successful Counter Unmanned System all three have to be integrated to detect the smallest of drones, track it during its flight and then neutralise it before it reaches its intended target. Each of these steps in itself gives a segment within the Counter Unmanned Systems Vertical.

- **Detection**.
  - **Radar Systems.** Specialised radars with the capability to detect low RCS flying objects detect small, slow, low-altitude UAVs.
  - **Radio Frequency (RF) Scanners.** Monitor drone communication links and control signals to identify flying drones.
  - **Electro-Optical/Infrared (EO/IR) Cameras.** Passively use visual and thermal imaging for identification.
  - **Acoustic Sensors.** Detect unique sound signatures of drone motors and feed them into the C UAS system.
  - **AI-Driven Sensor Fusion**. This then combines radar, RF, and optical inputs for high accuracy to detect small drones.

- **Tracking & Identification**
  - **Multi-Sensor Fusion.** There are today AI and ML algorithms which, after detection, classify drones as friendly, neutral, or hostile for timely tactical decisions.
  - **GIS-Based Air Picture.** Tells the C-UAS operator what the aerial picture is displaying.
  - **Secure Data Networks.** These are required to share real time encrypted information across formations to get the Aerial UAVs picture.
  - **Persistent Tracking**. Continuous monitoring using various electro-optical, radar tech, acoustics etc is required to locate and finally neutralise UAVs. For this use of LIDAR & Laser Range Finders is also resorted to for precise distance measurement and tracking.

- **Neutralisation**. Of drones or UAVs is carried out through soft kill or non-destructive methods and hard kill or destructive methods.
    - **Soft-Kill (Non-Destructive).** Has various methods, and each becomes a segment in the C-UAS vertical in the overall scheme. These methods are, however, less effective against autonomous drones with pre-programmed routes. The soft kill methods are given below for better understanding:
        - RF jamming which blocks communication between the drone and operator, sending the UAV in a different direction than the intended target.
        - GPS spoofing sends false navigation signals to mislead UAVs to another direction than the target.
        - Cyber takeover is used to hijack the control link of the UAV and then to land or redirect it elsewhere.

    - **Hard-Kill (Destructive).** Like the soft kill, there are various methods, and a lot of research is going on to improve these. Each such method provides a segment to be improved in the C-UAS ecosystem.
        - Weapon based systems use programmable airburst munitions which are cost-effective against mass drone attacks.
        - Missile interceptors have a very high success rate but are not very economical. (e.g., a Patriot missile costing millions vs a $20–50k drone).
        - Interceptor Drones are the new attraction in the defence systems; these are designed to collide or capture hostile drones.
        - Directed Energy Weapons (DEWs) or Lasers and high-power microwaves disable or burn the electronics of the UAVs, proving to be very low cost per-shot.
        - Net Capture Systems are a bit more complex methods where nets are launched from ground or interceptor drones to entangle UAVs.

Ammunition and Explosives

Warfighting has increasingly become kinetic in nature, where ammunition ranges from bullets to missiles, and the need to propel them towards the target accurately so as to achieve the desired destruction at the target. In addition to these, there is always a need to blow up structures like bridges, rock faces, etc, for increasing one's own mobility while reducing the adversary's mobility. Now let us look at these segments separately.

- **Ammunition.** From being used in close combat (small arms ammunition), there is a requirement of area suppression (small arms ammunition in machinegun role, infantry support weapons like mortars and light and field artillery ammunition). There is also a requirement of destruction of the enemy's assets deep inside his territory, for this, long-range medium- and heavy-artillery ammunition, rockets and missiles are needed. If these are to be used from an aircraft then a different air to surface segment of ammunition comes into place, similarly if destruction of aircraft is desired then surface to air ammunition segment is desired. Both these may be bullets, exploding shells, guided / unguided rockets or even short-range, medium-range and long-range missiles. This ammunition may be direct fired or indirect fired, unguided (high volume and low costs) for area saturation or precision (low volume and high costs) guided to accurately strike the target, it may also be a sedentary one like the land mines both anti-personnel and anti-armour.[11] The ammunition has the following components based on its design:

    - **Propellants.** The ammunition, whether it is a 9mm bullet or the largest missile, needs to be sent towards the target. For this there is a requirement of propellants of different kinds. These may be used to push the ammunition (bullets, artillery rounds etc) expending all stored chemical energy in an instant or assisted propulsion during the flight of the ammunition (Rockets and missiles) slowly releasing the stored chemical energy as required.
    - **Warhead.** The destruction required at the target end is carried out by the warhead. This is a very specialised segment as it may start from a lead bullet for killing soldiers, to an air burst round with a highly technical fuse,

to an artillery or missile warhead with a proximity fuse. Then the warhead may need to penetrate armour, thus being made of pure tungsten or another chemical explosive for scab effects. The warhead may need to explode at a measured standoff distance for the most destructive power, spread shrapnel for a greater killing area or use its explosive power to destroy structures.

- **Casing.** From copper casing for lead bullets to composite material for missiles and rockets to other metallic ones for artillery shells. Each type of ammunition requires a different kind of casing, and these form part of the ammunition ecosystem.
- **Fuse**. Different kinds of fuses are used for different kinds of ammunition. Some are impact fuses that will make the ammunition explode on impact, and some are delayed action that will wait for a definite time before initiating the explosive. While there are some that emit RF waves and initiate explosions when in near proximity of the target. Some fuses also explode when sufficient weight is placed on them or the ammunition, they are in (mines).

- **Explosives.** There is a wide range of explosives that are used in the armed forces. These are used for mainly two purposes, increasing own mobility by reducing obstacles in the areas leading towards the approach of tactical operations and reducing the adversary's mobility by destruction of infrastructure loke bridges, railway lines, communication networks etc. There are a multitude of such explosives, and as per their tasks these can be categorised as:
  - Demolition and breaching, like the plastic explosives, TNT, C-4, semtex etc.
  - Engineering & clearing, like ANFO, Slurries, Emulsions
  - Warhead Bomb Filling Explosives Composition B, Tritonal, torpex which are castable in nature.
  - Polymer-Bonded Explosives (PBX) used for precision warheads in high-cost Precision Guided Munition.

Simulators & Tactical Training Systems

Training is very time-consuming and costly if carried out in the traditional old methods. With the improvement in technology, near-real-life training can be imparted to all the soldiers, airmen and sailors. However, it should be noted that only live exercises provide all the tangible and non-tangible experience that will be nearest to the conflict spectrum.[12] Based on technology, these simulators can be configured for any kind of training, each in itself is a segment in this vertical, and these are categorised as follows:

- **Live Virtual and Constructive (LVC) Framework Simulators**. Are those that use a foundational framework to categorise training technology by the relationship between the operator and the system? Within this, there is the Live Simulation (Real People, Real Hardware) is where soldiers operate actual equipment in the field against simulated threats, e.g., the U.S. Army's MILES system attached to real rifles and tanks. The Virtual Simulation (Real People, Fake Hardware) where humans control simulated equipment, platforms, or weapon stations, e.g., Cockpit mock-ups, replicated steering assemblies etc. Lastly, the Constructive Simulation (Fake People, Fake Hardware) in which Computer-controlled forces interact in a completely digital environment, used by command staff to simulate entire theatre campaigns, supply chains, and enemy movements etc.

- **Display and Immersion Systems Simulators.** These are differentiated by how they present the visual environment to the trainee. These may use Dome and Projection Displays where Multiple high-definition projectors beam a seamless, 180-to-360-degree field of view onto a physical, curved structure. They may also use Extended Reality (XR: VR/AR/MR) where headsets replace or enhance the physical room, cutting down the footprint and cost of heavy projection domes. Lastly these may be Mixed/Augmented Reality (MR/AR) where high-resolution pass-through cameras (like Varjo headsets) let a pilot see their real physical hands and cockpit buttons, while the window view shows a fully simulated combat zone.

- **Kinematic and Motion Fidelity Simulators.** These classify simulator systems by how accurately they physically mimic real-world movement and forces (G-forces, turbulence, and rough terrain). They may be 6-DOF (Degrees of Freedom) Motion Platforms using hydraulic or electric hexapod legs to move the simulator cabin along all spatial axes (pitch, roll, yaw, surge, heave, and sway) or Static / Part-Task Trainers (PTT) which are fixed base systems with zero motion. They focus purely on muscle memory for button sequences, weapon loading, or radar screens.

- **Software and Network Architectures Simulators.** Are those that are classified by the underlying software engines and the network standards that allow them to talk to each other? These may be Commercial-Off-The-Shelf (COTS) Simulation Software or Distributed Network Standards (DIS / HLA), where the software protocols allow entirely different simulator technologies to connect.

Personal Protection & Troop Comforts

These segments given below are not just about comfort; they directly impact combat effectiveness, morale, and survivability in modern warfare. One needs to understand that troop protection and comfort are force multipliers, reducing attrition and enhancing operational readiness.

- **Ballistic Protection (Jackets, Helmets).** A soldier needs every chance to avoid injury and death, for personal protection, he today uses Ballistic Protection Jackets and Helmets. These are made from various materials such as Kevlar, Ultra High Molecular Weight Polyethylene, ceramic plates, etc. These are modular in structure so that, depending on the threat levels, more add-on armour plates can be added. NATO document STANAG 4569 defines six standardised NATO protection levels from 1 to 6. For personal protection, Stanag Levels 1,2 & 3, critical benchmarks for ballistic jackets and helmets from small arms and bomb fragments. Within the helmet and jackets are built attachments to integrate Night Vision Devices, Communication systems etc. The industry trend is to improve ergonomics, introduce embedded body sensors for health monitoring and reduce weight while increasing protection.

- **Extreme Temperatures Gear.** The purpose of such gear is to ensure troop survivability and operational efficiency in extreme temperatures and humidity. The key features improve insulation from extreme heat and cold while ensuring breathability of the gear, a must in high-humidity areas. Usually light-weight layered clothing, with high thermal efficiency. The industry trend is to make these as tough as possible without losing on troop comfort, with anti-microbial coatings to reduce infection risks in prolonged deployment.

- **Shelters and Tents.** An army needs shelter wherever they move; these need to provide protection, comfort, and sustainability during prolonged field operations. These can be tents made up of weather resistant, flame-retardant material which are easy to assemble in field conditions for temporary living. Then there are rapidly deployable modular insulated cabins with Nuclear Biological Chemical protection for a semi-permanent stay in field areas. The current industry trends are to make these shelters integrated with solar panels and climate control and to make them as light weight as possible for ease of portability and rapid deployment.

- **Life Cycle Clothing.** The clothing has mainly three layers, the innermost layer made up of Cotton blends, synthetics (polyester, nylon) or moisture wicking fabrics with Anti-microbial coatings and quick-dry properties. Then comes the Operational Layer (Combat Uniforms) which are durable, with camouflage patterns, reinforced stitching and can be integrated with protective gear, usually made up of Ripstop fabrics designed to resist tearing and ripping. Last is the jacket worn during mild cold temperatures.

Maintenance, Repair & Overhaul (MRO) Services

It is interesting to note that India has used both Western warfighting equipment and that of Russian origin. This gives a very unique identity in an industry where most countries either follow one or the other. With the use of such different equipment over decades comes a skill set of maintaining this varied equipment. While till recently, it was the tasks of the Public Sector Undertakings only, with policy changes in place and

the Private Sector willing to participate, MRO has become a very fast expanding Vertical in the Indian defence Industry.

- **Air Systems MRO**. It will be incorrect to state that only military aircrafts are being looked at for this segment. It will also cater for civilian aircraft and helicopters. With the cost competitiveness compared to OEM-based MROs, India is slowly becoming a huge hub for this segment. The market is not only Indian flying assets but also those of friendly foreign countries.

- **Sea Systems MRO**. It is a slowly developing segment, and the expertise of Indian shipyards for military MRO has been utilised by both the USA and the UK. The Master Shipyard Repair Agreement (MSRA) of the USA has been signed with the Mazagaon Dock Shipyard Limited and the L&T Shipyard. A similar agreement stands with the UK for naval ships. It is to be noted that merchant marine ships of many other countries have routinely used Indian shipyards for MRO purposes.

- **Land Systems**. This is not as big a segment today as the other two MRO segments. However, with the Indian expertise in maintain Russian T-72, T – 90 and even the older T-55 tanks and Infantry Combat Vehicles (ICVs) such as the BMP-2, BRDM etc the infrastructure and skill sets are waiting to be used. Algeria will probably be the first country to officially make use of Indian MRO services; many other African and Asian countries have been buying maintenance spares from India.[13]

New Emerging Technologies

A host of new emerging technologies that would have earlier been the mandate of only government agencies are now open for private players to invest in, support and even export the products. There is unlimited growth foreseen for these, and India hopes to become a global leader in most the times to come. Some very interesting segments in this vertical are given below.

- **Directed Energy Weapons (DEWs).** DEWs are advanced systems that use concentrated electromagnetic energy, such as lasers, microwaves, etc to

disable, damage, or destroy targets. They promise precision, low cost per shot, and effectiveness against drones, rockets, and electronics. These can be High Energy Lasers, Millimetre Wave Weapons operating in the 1-10mm wavelength or High-Power Microwave Weapons. These can be non-lethal temporarily disabling electronics or lethal melting and destroying critical electronic components. The most significant advantages in the era of drone swarms are the low cost per shot and virtually unlimited ammunition (limited only by power supply). However, there are challenges like limited range, mobility due to the need of excessive energy, line of sight requirements, collateral risks, etc.[14]

- **Space Technology & Military Satellites.** Space has been the backbone of modern defence operations, enabling secure communication, surveillance, navigation, etc. Space technology provides global reach, resilience in contested environments, and support of various kinds for military operations. The core role of space technology would comprise secure communication, navigation, surveillance & reconnaissance, early warning of missile launches and Signals Intelligence (SIGINT). For these there is a requirement of satellites, not one or two but an unlimited constellation of satellites with the capability to perform these roles, stationed in the space and being increased or replaced as required. To place these satellites in space, there is a need for capable rockets. While ISRO is there, it is limited in scope and the volumes envisaged for the coming decades. The private industry has taken up the challenge, and rockets and satellites are being developed at a very enthusiastic pace, this is becoming a very fast-growing segment in the vertical.[15]

- **Cyber Defence, Artificial Intelligence & Quantum Technology.** Cyber Defence, Artificial Intelligence, and Quantum Technology are slowly becoming a unified framework of future warfare. Cyber defence is the shield protecting digital infrastructure, command networks, and weapon systems, forming the defensive backbone against cyber intrusions. Artificial intelligence is the new brain providing autonomy, predictive analytics, and accelerated decision making relying on secure sovereign cyber environments.[16] The game changer is quantum technology which provides breakthroughs in secure

communication, advanced sensing, and computing.[17] This is the future of warfare, positioning cyber, AI, and quantum as interdependent pillars that converge to reshape doctrines, force structures, and defence industry trajectories.

Conclusion

The Indian defence industry is rising, it is a quantifiable ascendancy in the global defence arena, building land, sea, and air systems. There is an opportunity to be a part of this phenomenon, an opportunity for the innovator, for the investor, for the MSMEs and the established industry, to build indigenous capabilities across land, sea, air, unmanned systems, and support services. Each vertical, whether aircraft manufacturing, naval shipbuilding, advanced munitions, simulators, or troop protection, offers immense scope for innovation, investment, and collaboration. The most interesting advances will be seen in the drones, anti-drone and the new emerging technologies ecosystems. For India to be strategically autonomous, each segment contributing to each of these specific verticals needs to be indigenised, and therein we find such vast and diverse opportunities.

Declaration

I declare that this manuscript is being submitted exclusively to CENJOWS for publication consideration, is original, and has not been published or submitted elsewhere. I further certify that it contains no classified, restricted, or sensitive information and is based entirely on open-source material suitable for publication in the public domain.

ENDNOTES

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