FROST & SULLIVAN

Assessment of Global and Indian Defence Electronics and Technology Industry

December 2025

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Glossary

A2/AD	Anti-Access/Area Denial
AESA	Active Eslectronically Scanned Array (radar).
AEW&C	Airborne Early Warning and Control
AI	Artificial Intelligence
AMCA	Advanced Medium Combat Aircraft
AMRAAM	Advanced Medium-Range Air-to-Air Missile
API	Application Programming Interface
ASW	Anti-Submarine Warfare
ATGM	Anti-Tank Guided Missile
ATR	Automatic Target Recognition
AUKUS	Australia–United Kingdom–United States security pact
AWACS	Airborne Warning and Control System
BEL	Bharat Electronics Limited
BMS	Battlefield Management System
BVRAAM	Beyond-Visual-Range Air-to-Air Missile
C2	Command and Control
C4I	Command, Control, Communications, Computers & Intelligence
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance & Reconnaissance
C4ISTAR	Command, Control, Communications, Computers, Intelligence, Surveillance, Target Acquisition & Reconnaissance
CABS	Centre for Airborne Systems
CAGR	Compound Annual Growth Rate
CBRN	Chemical, Biological, Radiological & Nuclear
CMOS	Complementary Metal-Oxide Semiconductor (imager)
CNI	Communications, Navigation & Identification
COMINT	Communications Intelligence
COTS	Commercial Off-The-Shelf
CPI	Consumer Price Index
C-UAS	Counter-Uncrewed/Unmanned Aerial Systems
CY	Calendar Year
DAP (2020)	Defence Acquisition Procedure (India, FY2020)
DBT	Direct Benefit Transfer
DCPP	Development-cum-Production Partner (India)
DDTC	(U.S.) Directorate of Defense Trade Controls
DEAD/SEAD	Destruction / Suppression of Enemy Air Defenses
DEW	Directed Energy Weapon
DES	Directed Energy Systems
DIANA	Defence Innovation Accelerator for the North Atlantic (NATO)
DIAT	Defence Institute of Advanced Technology (India)
DMA	Department of Military Affairs (India)
DoD	(U.S.) Department of Defense
DPEPP	Defence Production & Export Promotion Policy (India)
DPSU	Defence Public Sector Undertaking
DRDO	Defence Research & Development Organisation (India)
EAR	(U.S.) Export Administration Regulations
ECCM	Electronic Counter-Countermeasures
ECM	Electronic Countermeasures
ELINT	Electronic Intelligence
EMP	Electromagnetic Pulse
EO	Electro-Optical
EOFC	Electro-Optical Fire-Control (system)
EOTS	Electro-Optical Targeting System

EO/IR	Electro-Optical/Infrared
ESM	Electronic Support Measures
EW	Electronic Warfare
FCAS	Future Combat Air System (EU)
FICV	Future Infantry Combat Vehicle (India)
FRCV	Future Ready Combat Vehicle (India)
FSO	Free-Space Optical (communications)
FMF	Foreign Military Financing (U.S.)
FMS	Foreign Military Sales (U.S.)
FY	Financial Year
G2G	Government-to-Government
GEOINT	Geospatial Intelligence
GLATGM	Gun-Launched Anti-Tank Guided Missile
GMTI	Ground Moving Target Indication (radar mode)
GNSS	Global Navigation Satellite System
GPU	Graphics Processing Unit
GPS	Global Positioning System
GVA	Gross Value Added
HALE	High-Altitude Long-Endurance (UAS)
HAPS	High-Altitude Pseudo-Satellite
HEL	High Energy Laser
HELWS	High Energy Laser Weapon System
HF/VHF/UHF	High Frequency/Very-High Frequency/Ultra-High-Frequency
HPM	High-Power Microwave
HUMINT	Human Intelligence
HUMS	Health & Usage Monitoring System
IAF	Indian Air Force
iCET	U.S.–India Initiative on Critical & Emerging Technology
iDEX	Innovations for Defence Excellence (India)
IIR	Imaging Infrared (seeker/sensor)
INS	Inertial Navigation System
IR	Infrared
IRDE	Instruments Research & Development Establishment (DRDO)
IRST	Infrared Search & Track
ISR	Intelligence, Surveillance & Reconnaissance
ITAR	International Traffic in Arms Regulations (U.S.)
IIT	Indian Institute(s) of Technology.
IISc	Indian Institute of Science
JADC2	Joint All-Domain Command and Control (U.S.)
JDAM	Joint Direct Attack Munition
LAC	Line of Actual Control
LiDAR	Light Detection and Ranging
LoC	Line of Control
LOS	Line of Sight
LR-LACM	Long-Range Land-Attack Cruise Missile
LRF	Laser Rangefinder
LWIR/MWIR/ SWIR	Long-/Mid-/Short-Wave Infrared
MALE	Medium-Altitude Long-Endurance (UAS)
MASINT	Measurement & Signature Intelligence
MANET	Mobile Ad-hoc Network
MAWS	Missile Approach Warning System
MDO	Multi-Domain Operations
mmW	Millimetre-Wave
MR-SAM/ MRSAM	Medium-Range Surface-to-Air Missile
MSME	Micro, Small & Medium Enterprises

M-SHORAD	Maneuver Short-Range Air Defense
NATO	North Atlantic Treaty Organization
NavIC	Navigation with Indian Constellation (India's GNSS)
NIR	Near-Infrared
NLOS	Non-Line-of-Sight
NSM	Naval Strike Missile
OEM	Original Equipment Manufacturer
OODA	Observe–Orient–Decide–Act (decision loop)
OSINT	Open-Source Intelligence
OSIR	Observation–Surveillance, Imaging & Reconnaissance
PA-DS	Public Administration, Defence & Other Services (sector in India's national accounts)
PAI	Publicly Available Information (paired with OSINT)
PESCO	Permanent Structured Cooperation (EU)
PGM/PGMs	Precision-Guided Munition(s)
PM-JAY	Pradhan Mantri Jan Arogya Yojana (health insurance scheme)
PM-POSHAN	PM Poshan Shakti Nirman (school meals programme)
PNT	Positioning, Navigation & Timing
PSU	Public Sector Undertaking (India)
PWGS	Precision Weapon Guiding Systems
QR-SAM	Quick Reaction Surface-to-Air Missile
R&D	Research & Development
RBI	Reserve Bank of India
RF	Radio Frequency
ROI	Return on Investment
RWS	Remote Weapon Station
SAL	Semi-Active Laser
SAR	Synthetic Aperture Radar
SATCOM	Satellite Communications
SCOMET	Special Chemicals, Organisms, Materials, Equipment & Technologies
SDB	Small Diameter Bomb
SIGINT	Signals Intelligence
SIPRI	Stockholm International Peace Research Institute
SoC	System-on-Chip
SWaP/SWaP-C	Size, Weight & Power/-Cost
TDF	Technology Development Fund (India)
UAS/UAV	Unmanned Aerial System/Unmanned Aerial Vehicle
UCAV	Unmanned Combat Aerial Vehicle
UGV	Unmanned Ground Vehicle
UGS	Unattended Ground Sensor
UMANG	Unified Mobile Application for New-age Governance (India)
VOx	Vanadium-Oxide (uncooled IR detector material)
VSHORADS	Very Short-Range Air Defence System
WPI	Wholesale Price Index

1 Global Macro-Economic Overview

1.1 Overview of Global GDP

In CY2025, the global economy is projected to grow at a muted pace, shaped by persistent geopolitical tensions, tariff regimes, and regional conflicts. After a post-pandemic rebound in CY2021, output has gradually slowed, with the IMF forecasting 2.8% growth in CY2025 and 3.0% in CY2026—well below the pre-pandemic average of 3.7%. The slowdown reflects tighter financial conditions, weaker trade and investment, and the disruptive impact of U.S. universal tariffs imposed in April CY2025.

Advanced economies are expected to expand by just 1.4% in CY2025, led by the U.S. at 1.8%, while Europe lags at 0.8% amid energy disruptions, subdued manufacturing, and weak household consumption. Ongoing conflicts in Ukraine and the Middle East continue to weigh on trade and spending, though headline inflation is easing. Still, persistent core inflation will keep central banks cautious.

Emerging markets and developing economies (EMDEs)—a category defined by the IMFto include low-and middle-income countries with developing financial markets and industrial capacity—remain the main growth engine, with output rising 3.7% in CY2025 and 3.9% in CY2026. India leads with 6.5% growth, reinforcing its role as Asia's economic locomotive, while Southeast Asia shows resilience despite global headwinds. China's growth, forecast at 4.6% in CY2026, remains below expectations, held back by structural property market issues and weaker external demand. Broader EMDE risks include elevated debt, currency weakness, and constrained borrowing amid tighter global financial conditions.

The IMF had projected 3.3% global growth at the start of CY2025, but policy instability and trade fragmentation in the first half of the year have since lowered forecasts. Inflation is expected to average 4.3% in CY2025 and moderate to 3.6% in CY2026, remaining above target levels. To preserve stability, coordinated policy efforts, productivity reforms, and targeted financial support will be critical.

Table 1: Global GDP Growth Forecasts

Calendar Year (CY)	World GDP (% Change)	Advanced Economies (% Change)	EMDEs (% Change)
2020	(2.7)	(4.0)	(1.7)
2021	6.6	6.0	7.0
2022	3.6	2.9	4.1
2023	3.5	1.7	4.7
2024	3.3	1.8	4.3
2025 (F)	2.8	1.4	3.7
2026 (F)	3.0	1.5	3.9
2027 (F)	3.1	1.7	4.0

Source: IMF

1.2 GDP Growth Across Key Strategic Countries

Over the past decade, the global economy has experienced sharp cycles of contraction and recovery. From CY2007–CY2016, world GDP growth averaged 3.4%, but the COVID-19 pandemic triggered a 2.7% contraction in CY2020 (advanced economies -4.0%, EMDEs -1.7%). This was followed by a sharp rebound in CY2021, with global growth of 6.6% (advanced economies +6.0%, EMDEs +7.0%).

1.3 Growth Outlook of Key Economies

United States: Growth is expected to slow to 1.8% in CY2025 (from 2.7% in CY2024) due to broad tariffs introduced in April CY2025, which have disrupted trade and dampened consumer spending. Despite strong labor markets and initial resilience in household demand, uncertainty and restrictive trade policies are weighing on business investment. Inflation remains elevated, requiring a cautious monetary stance. Growth is projected to stabilize near potential at 1.9% in CY2026.

European Union: Output is forecast to rise only 0.8% in CY2025, reflecting persistent policy uncertainty, elevated energy costs, and weak manufacturing momentum. Germany's industrial slowdown contrasts with relative resilience in Spain and France, supported by services and consumption. Growth could rebound to 1.4% in CY2026 if geopolitical tensions ease and consumer confidence improves.

Japan: GDP is projected to expand by just 0.6% in CY2025, with a modest uptick to 0.8% in CY2026. Structural headwinds—aging demographics, tepid domestic demand, and export weakness—continue to suppress momentum. Supply chain disruptions and limited fiscal space compound constraints, even as monetary policy remains accommodative.

China: Growth is expected at 4.6% in CY2025, supported by fiscal stimulus and infrastructure investment, though tariffs and supply chain realignment weigh on external demand. The real estate sector shows tentative recovery amid improved investor confidence. Output is forecast to hold at 4.5% in CY2026, underpinned by policy support and gradual strengthening of household consumption.

India: Remaining the fastest-growing major economy, India is projected to sustain 6.5% growth in both CY2025 and CY2026. Expansion is driven by robust private consumption, strong public investment, and favorable demographics. Structural reforms, digital infrastructure, and improvements in the ease of doing business are reinforcing industrial and services sector momentum, cementing India's role as a global growth leader.

1.4 Growth Outlook on Key Emerging Markets

Emerging markets are navigating a complex economic landscape shaped by geopolitical fragmentation, inflation volatility, and evolving investor sentiment. According to Emerging Markets Outlook CY2025, these economies are showing resilience amid global challenges, although growth projections vary by region.

Latin America and the Caribbean: It is expected to grow at 2.5% in CY2025, with Brazil and Mexico showing moderate but steady performance. Inflation is stabilizing, but fiscal imbalances and external vulnerabilities continue to weigh on the region. Political uncertainty and commodity price fluctuations remain key risks.

Middle East and Central Asia: It is projected to grow at a rate of 3.0% in CY2025 and is tempered by geopolitical tensions and oil production cuts. The region also faces capital flow pressures due to stronger US dollar dynamics. However, diversification efforts in Gulf economies and increased infrastructure spending provide some upside.

Emerging Asia: Countries such as India, Indonesia, the Philippines, and Vietnam are poised for robust growth, with India leading at 6.6%. Flexible exchange rates and credible central bank policies have helped moderate inflation. Nonetheless, supply chain disruptions and weaker global demand could challenge exports.

Sub-Saharan Africa: It is forecasted to grow by 3.8% in CY2025, benefiting from improved commodity prices and IMF-supported economic programs. However, double-digit inflation persists in countries like Nigeria, Ghana, and Zambia, driven largely by food price surges and currency depreciation.

Emerging and Developing Europe: In these regions, growth is expected to remain modest at 2.1% due to the prolonged impacts of the Russia-Ukraine war. Poland and Romania have shown resilience, but energy insecurity and high inflation pose significant hurdles to sustained recovery.

While emerging markets are not immune to global shifts, they are adapting through alternative trade alignments, domestic policy buffers, and increased participation in renewable energy transitions. Investor confidence is gradually returning, particularly in countries like India and Brazil, supported by structural reforms and stable macroeconomic management.

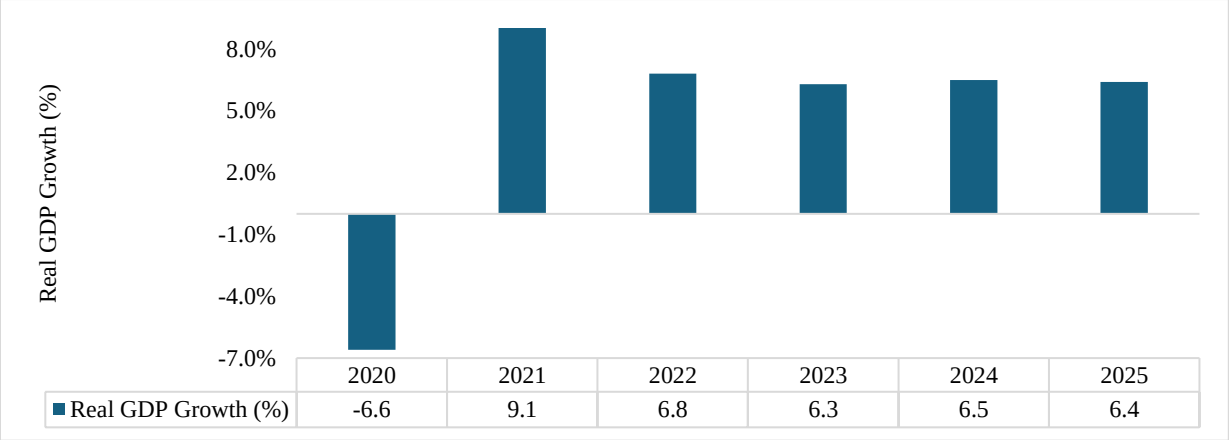
2 India's Macro-Economic Overview

India enters FY2025 as one of the fastest-growing major economies, with GDP growth at 6.5% projected by both the government and RBI for FY2025–26. This resilience is striking against a backdrop of global uncertainty—geopolitical tensions, supply chain disruptions, and tighter financial conditions. Growth is underpinned by robust domestic demand, infrastructure spending, a dynamic services sector, and digital transformation.

Inflation trends are mixed. Wholesale Price Index (WPI) inflation fell to 0.39% in May FY2025, a 14-month low driven by declining food prices (vegetables, cereals, edible oils). This disinflation eases input cost pressures and could soften retail prices in the coming months. By contrast, Consumer Price Index (CPI) inflation remains sticky—193.4 in Jan FY2025 rising to 196.0 in July—with persistent pressures from services and non-food categories, highlighting lagged transmission from wholesale to retail.

2.1 GDP Growth in India

Figure 1: IMF World Economic Outlook Database, FY2020-2025



Source: IMF

India has demonstrated a strong recovery since the pandemic-induced contraction in FY2020. India's projected GDP growth of 6.4% in FY2025 reflects strong domestic consumption, public investment, and digital expansion. The continued softening in WPI down to 0.39% in May FY2025 is likely to reduce industrial input costs, enhance profit margins in core sectors like manufacturing and construction, and support consumption. This easing inflationary environment is expected to boost real income, improve purchasing power, and strengthen the economic sentiment that supports India's growth trajectory.

2.2 Public Administration, Defense, and Other Service Sector GVA Growth

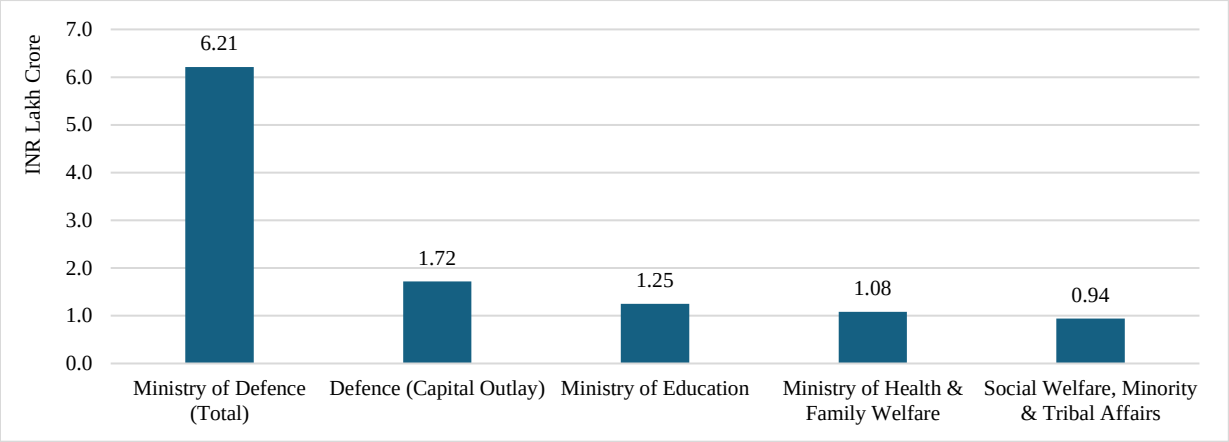
In India's economy, the Public Administration, Defence and Other Services (PA-DS) sector is foundational — it accounted for 14.5% of total Gross Value Added in FY2024–25 (current prices), making it one of the largest individual contributors within the Services domain. As part of the broader Services sector, which comprised 54.9% of Gross Value Added (GVA), PA-DS alone represents over a quarter (~26%) of Services output, signaling its critical importance in delivering governance, national security, and welfare services to over a billion citizens.

Key Growth Drivers in FY2024–25:

- **Government Spending:** The Union Budget FY2025–26 allocated significant resources to defense capital outlay (~INR 1.72 lakh crore), social schemes (PM-JAY, PM-POSHAN), and IT infrastructure to enhance governance, all supporting multiplier effects across industrial supply chains.
- **Digital Governance Push:** Expanded adoption of UMANG, Digi Locker, and API-based e-Governance modules drove administrative efficiencies and transparency, bolstering public confidence and inclusive service delivery.
- **Welfare-Oriented Schemes:** Continued focus on Ayushman Bharat (PM-JAY), the National Education Mission, and skill development schemes fueled GVA growth through public-sector investments.

- **Defense Sector Modernization:** Accelerated procurement of indigenous platforms, light combat aircraft, artillery, advanced optical sensors, surveillance payloads, and drone systems created new demand for specialized companies like Tonbo Imaging that support India's network-centric warfare ambitions.
- **Urban & Rural Administration:** Mission-driven programs like Smart Cities, Swachh Bharat Mission 2.0, and the e-Gram Swaraj portal streamlined last-mile service delivery and increased public-sector job creation at local levels.

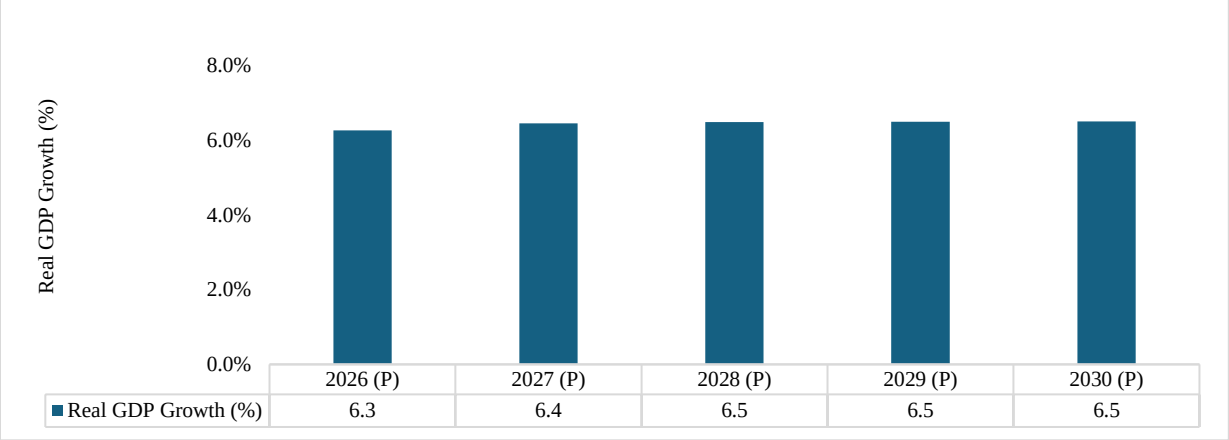
Figure 2: Capital Allocation FY2025–26



Source: Frost & Sullivan Analysis, Union Budget of India (April FY2025)

2.3 GDP Growth Outlook in India (FY2026-2030)

Figure 3: IMF World Economic Outlook, FY2026-2030



Source: Frost & Sullivan Analysis, IMF

Baseline forecasts point to real GDP growth of 6.3% in FY2026, 6.4% in FY2027, and 6.5% annually through FY 2028–30. Momentum is anchored by resilient domestic demand, sustained public capex, healthier bank/corporate balance sheets, and digital public infrastructure, with inflation broadly around target; key downside risks are weaker external demand, oil-price shocks, and weather-driven food inflation, while deeper reforms could lift potential growth.

3 Geopolitical Context

3.1 Key Conflicts, Wars, and Tensions Globally

Geopolitical instability continues to define the global risk landscape in CY2025, shaping energy markets, trade corridors, defense strategies, and inflation trajectories. Several active and latent conflict areas are expected to impact global security and economic policies:

- **Russia–Ukraine War:** Now in its fourth year, driving NATO support, sanctions, and disruptions in European energy and agricultural supply chains.
- **Israel–Hamas Conflict and Regional Escalations:** Israel-Hamas conflict has deescalated but tensions remain. Ongoing hostilities involving Hezbollah and instability across the Red Sea, jeopardizing shipping lanes and regional security.
- **Indo-Pacific Tensions:** Rising friction between China, Taiwan, and the United States, with heightened military drills, risks to the semiconductor supply chain, and cyber warfare threats.
- **India's Border Pressures:** Persistent tensions along the LoC with Pakistan and the LAC with China, with India focusing on infrastructure buildup and surveillance in high-altitude zones.
- **Middle East Militancy:** ISIS breakaway groups in Syria/Iraq and Houthi actions in Yemen creating instability near vital shipping lanes and oil transit routes.

Together, these flashpoints are redrawing defense priorities, multilateral alliances, and trade strategies across NATO, ASEAN, GCC, and QUAD nations.

In recent years, geopolitical instability, such as border conflicts, rising regional tensions, and emerging non-state threats, has led to accelerated procurement through emergency purchase mechanisms and fast-track acquisitions. These mechanisms are designed to address immediate operational needs, leading to sudden spikes in demand for defence electronics. While this has created short-term demand spikes, such procurement cycles are episodic and may not be sustained if geopolitical tensions subside or governments revert to conventional, multi-year acquisition programs. The episodic nature of emergency procurement leads to fluctuations in order volumes and revenue, making it difficult for companies to forecast and plan long-term investments or resource allocation. Consequently, revenue visibility can be inconsistent, and conversion of opportunities from the broader Total Addressable Market ("**TAM**") and Serviceable Addressable Market ("**SAM**") often remains a prolonged, resource-intensive process in the absence of conflict-driven urgency.

3.2 Key Drivers for the Rising Demand of Defense Technologies

In the current global context, several key drivers have significantly shaped defense priorities and technology investments worldwide:

- **High-Intensity Conventional Warfare**: Conflicts such as Russo-Ukraine have highlighted gaps in artillery, air defense, and logistics, spurring investments in long-range fires and integrated air-defense networks.
- **Asymmetric Warfare and Drone Usage:** The extensive use of UAVs in Ukraine and Gaza is accelerating demand for counter-drone systems including jammers, radars, and directed-energy weapons.
- **Cyber Warfare and Digital Battlespace Vulnerabilities:** Increasing cyber threats on infrastructure are pushing defense agencies to expand cyber-intelligence, intrusion detection, and resilient C2 networks.
- **Militarization of Space and Maritime Domains:** Rising anti-satellite capabilities and naval activity in chokepoints are driving demand for Intelligence, Surveillance, and Reconnaissance (ISR) assets, including Electro-Optical/Infrared payloads and maritime reconnaissance systems.

3.3 Rise in Global Terrorism, and Counter-Terrorism Capabililties

As of CY2025, global terrorism has witnessed a significant resurgence driven by both state-sponsored actors and non-state militant groups. These actors increasingly leverage advanced technologies, decentralized networks, and hybrid warfare strategies to evade conventional security apparatuses. The complexity and reach of terrorist threats have expanded beyond traditional theaters of conflict like the Middle East and South Asia to cyberspace and urban centers worldwide.

Key Regions Impacted:

- **Middle East:** After the defeat of ISIS's territorial in CY2019, ISIS splinter groups have resurfaced in Syria and Iraq, adjusting their tactics to guerrilla insurgencies and cross-border raids to maintain their presence and influence. At the same time, the Houthi militia from Yemen, which has been active since the beginning of the Yemen civil war in CY2015, has increased threats to commercial shipping and maritime security in the Red Sea, notably since CY2023, and is contributing to the upsurge of regional instability even till today.
- **South Asia:** Persistent terrorism in Jammu & Kashmir and a resurgence of Tehrik-i-Taliban Pakistan (TTP) underscore the region's volatility. Following the Taliban's takeover in Afghanistan, terrorist safe havens have re-emerged across border areas, increasing infiltration attempts into India and Central Asia.
- **Africa:** Boko Haram, Al-Shabaab, and ISWAP continue to pose serious threats across Nigeria, Mali, Somalia, and other Sahel nations. These groups exploit political instability, ethnic strife, and porous borders to expand their control and influence.
- **Europe & North America:** Developed nations face a new surge of lone-wolf attacks inspired by online extremist content and radical ideologies. Soft targets such as cultural venues, public gatherings, embassies, and transport networks remain highly vulnerable.

3.3.1 India's Counter Terrorism Strategy

India remains a prominent target of cross-border terrorism, primarily due to its long-standing conflict with Pakistan and ongoing security challenges along its western and northern borders. This is compounded by India's ongoing physical border tensions with China, which are driving defense agencies to enhance cyber-intelligence, intrusion detection, and resilient command-and-control capabilities. These threats have driven a sustained focus on modernization of forces, intelligence integration, and proactive counter-terrorism measures.

Key Initiatives:

- **Modernization of Forces:** Procurement of bullet-proof armored vehicles, long-endurance UAVs for continuous surveillance of border regions, and AI-enabled facial recognition at key transit points.
- **Strengthening Intelligence Apparatus:** Upgrading of NTRO (National Technical Research Organization), bolstering multi-agency coordination hubs, and leveraging big data analytics to track suspect movements and communications.
- **Smart Policing & Internal Security:** Expansion of CCTNS (Crime and Criminal Tracking Network & Systems), NATGRID (National Intelligence Grid), and smart city Command and Control Centers to integrate feeds from CCTV and sensors in urban areas.
- **Cyber Counter-Terrorism Units:** Creation of specialized cyber-intelligence task forces under the MHA and defense agencies to trace digital radicalization and dismantle financing channels.

3.4 India's Geopolitical Context

India's defense posture and spending reflect evolving global requirements alongside regional challenges, especially concerning its borders with China and Pakistan.

3.4.1 Budgetary Allocation and Modernization Focus

Key Initiatives Underway:

- **Indigenization:** Accelerating domestic production of next-generation platforms, including the Tejas Mk1A fighter jet, Dhanush howitzers, Akash surface-to-air missile systems, and Arjun MBTs.
- **Make in India for Defense**: Strengthening strategic partnerships with countries like Israel, France, and the U.S. for technology transfers in missile systems, jet engines, and naval propulsion. This supports India's ambitions to scale up local R&D, manufacturing, and skill development, while reducing imports.
- **Growth in Defense Exports**: India's defense exports surged to INR 23,622 crore in FY2024–25, up significantly from INR 1,521 crore in FY2016–17, driven by competitive pricing and demand for systems such as the BrahMos cruise missile, Pinaka multi-barrel rocket launchers, and advanced surveillance equipment.

3.4.2 India's Strategic Advantage as a Supplier

- **Cost-Effective Indigenous Systems**: Indigenous products like the Tejas Mk1A light fighter, Pinaka rocket system, and Arjun Main Battle Tank highlight India's engineering capabilities at competitive prices, attracting interest across Africa, Southeast Asia, and Latin America.
- **Neutral Strategic Posture:** India's long-standing policy of strategic autonomy allows it to supply defense hardware across different geopolitical blocs, appealing to countries diversifying their suppliers.
- **Vibrant Defense MSME Ecosystem:** Over 15,000 Micro, Small, and Medium Enterprises (MSMEs) contribute components such as avionics, electro-optical payloads, and cybersecurity software into DRDO and DPSU supply chains. Initiatives like Atmanirbhar Bharat and Make in India encourage joint ventures and co-production with international OEMs
- **Emerging Competitive Edge**: With ongoing investments in domestic R&D centers and dedicated defense corridors in Uttar Pradesh and Tamil Nadu, India is becoming a credible alternative to traditional suppliers in Europe and the U.S. Its exports, including advanced missiles, drones, and sensors, reinforced by competitive financing options, support India's emergence as a stable and capable supplier to the Global South and middle-income economies.

3.4.3 Evolution of Warfare and Industry

As modern warfare adapts to new age conflicts and disruptive technologies, defense industries face a transformative phase:

- **Militarization of Space:** Space is becoming a contested domain. Major powers deploy satellites for reconnaissance, communications, and targeting alongside anti-satellite (ASAT) capabilities. Nations must invest in space situational awareness (SSA), anti-jamming measures, and hardened satellites to ensure reliability in conflicts.
- **AI and Autonomous Warfare:** AI-driven combat, including swarm drone attacks, autonomous wingmen supporting fighter jets, and predictive maintenance, will shape future battlefields. Military planners aim to enhance real-time target recognition, threat prioritization, and logistics responsiveness. For instance, the U.S. Air Force's Skyborg program is working on artificial intelligence-enabled autonomous wingmen that will fly alongside piloted aircraft and perform both defensive and offensive roles.
- **Hybrid Warfare and Multi-Domain Operations:** Future conflicts will integrate kinetic strikes with information warfare, cyberattacks, and psychological operations. Protecting power grids, financial systems, and public morale will be as critical as traditional military engagements.
- **Collaborative R&D and Interoperability:** Alliances like QUAD, AUKUS, and I2U2 promote cooperative R&D in quantum computing, undersea warfare, AI, and hypersonic. Partner nations reduce costs and improve interoperability through co-development, cross-border consortia, and sharing intellectual property, delivering affordable, modular solutions for coalition operations.

Autonomous systems are transforming modern warfare by using AI, sensor fusion, and real-time decision-making to conduct faster, safer, and more precise operations with minimal human intervention. They reduce risk to personnel by handling dangerous tasks like mine clearance, reconnaissance, and contested airspace surveillance, extend operational reach, and process data at machine speed for accurate targeting and reduced collateral damage. Capable of rapid, adaptive responses in electronic, cyber, and kinetic domains, they enable swarming tactics for resilience and mission continuity. Rather than replacing humans, autonomy shifts their role from operators to strategic decision-makers, allowing machines to manage routine, hazardous, or time-critical tasks.

Going forward, the integrated systems in modern day battlefield are changing:

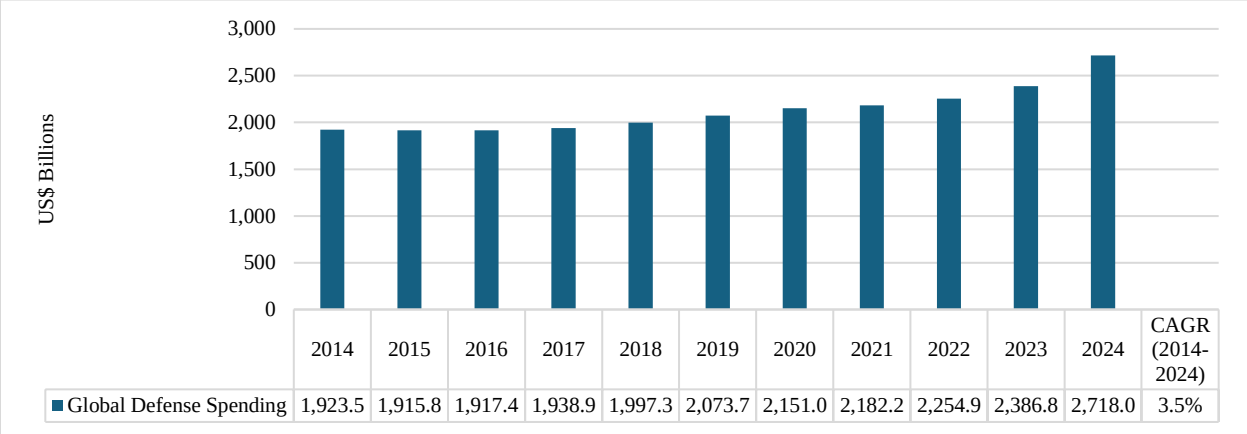
- Missiles are being replaced by loitering munitions
- Fighter aircrafts are making way for unmanned combat drones and need for counter-drone systems are becoming prevalent
- Tanks and heavy infantry vehicles are being replaced by more nimble unmanned ground vehicles with autonomous weaponry

4 Global Defence and Security

4.1 Global Defense Spending (CY2014-2024)

Global military expenditure reached USD 2,718.0 billion in CY2024, reflecting a 3.5% year-on-year growth in real terms—the sharpest annual increase since the end of the Cold War. This extends a ten-year expansionary cycle, with spending rising from USD 1,923.5 billion in CY2014, a 41.3% increase over the decade.

Figure 4: Global Defense Spending, CY2014-2024.



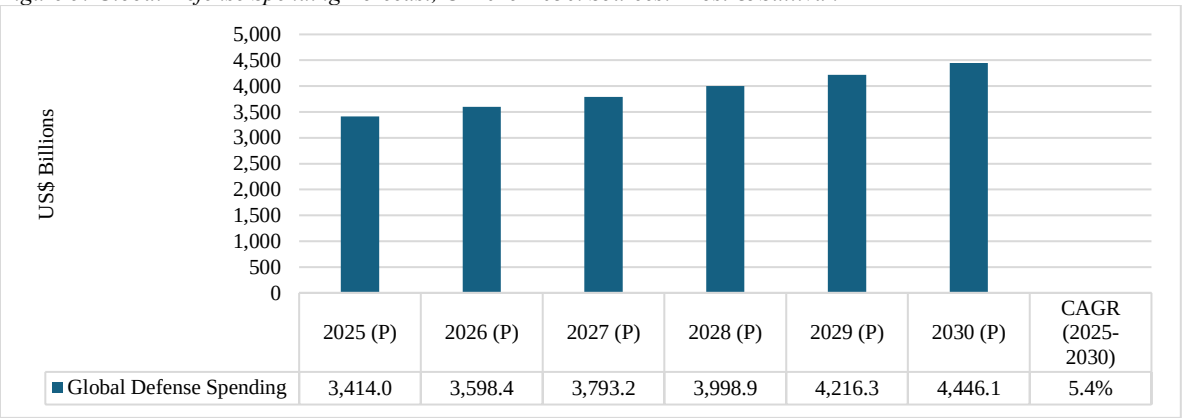
	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR (2014-2024)
Global Defense Spending	1,923.5	1,915.8	1,917.4	1,938.9	1,997.3	2,073.7	2,151.0	2,182.2	2,254.9	2,386.8	2,718.0	3.5%

Source: Frost & Sullivan

Defense spending increased across all major regions, driven by intensifying geopolitical tensions, heightened threat perceptions, and the modernization of legacy platforms across land, air, naval, and space domains. Notably, the top five spenders—United States, China, Russia, Germany, and India—accounted for over 60% of total global outlays between CY2014-CY2024, consolidating their position as the principal actors shaping the global defense landscape.

The global defense burden, defined as military expenditure as a percentage of GDP, rose from 2.1% in CY2014 to 2.5% in CY2024, marking a structural shift in fiscal priorities.Forecasted Global Defense Spending (CY2025-CY2030). Looking ahead, global defense spending is projected to rise from USD 3,414.0 billion in CY2025 to USD 4,446.1 billion by CY2030, representing a compound annual growth rate (CAGR) of 5.4% over the forecast period. This sustained increase is driven by both cyclical modernization and structural changes in threat environments and force restructuring initiatives.

Figure 5: Global Defense Spending Forecast, CY2025-2030. Sources: Frost & Sullivan



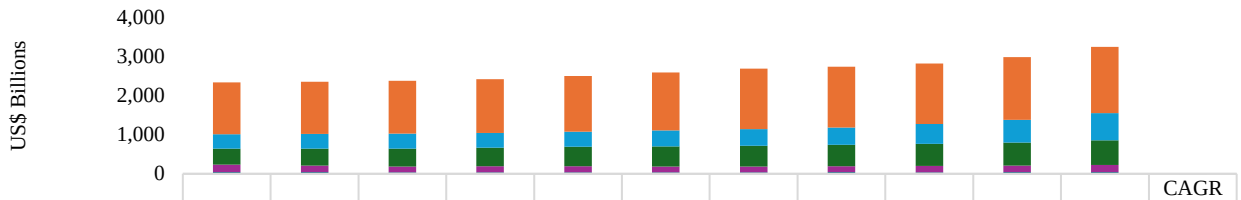
	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2025-2030)
Global Defense Spending	3,414.0	3,598.4	3,793.2	3,998.9	4,216.3	4,446.1	5.4%

Source: Frost & Sullivan

4.2 Global Defense Spending by Region

Global defense spending continues to record year-on-year growth, reflecting a broad reprioritization of national budgets toward military preparedness, shaped by regional threat perceptions, alliance dynamics, and budgetary headroom.

Figure 6: Global Defense Spending by Region, CY2014-CY2024.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR (2014-2024)
Americas	1,325.6	1,333.6	1,351.4	1,370.4	1,417.1	1,480.5	1,542.8	1,546.9	1,547.2	1,597.8	1,693.7	2.5%
Europe	362.2	371.5	383.1	375.6	384.8	405.1	427.4	439.7	505.0	581.5	693.0	6.7%
Asia & Oceania	409.3	434.3	455.8	476.5	496.9	513.6	531.6	547.3	559.5	587.7	624.7	4.3%
Middle East	192.0	168.5	141.6	152.0	157.6	149.6	140.8	153.2	161.8	158.9	179.0	-0.7%
Africa	44.0	42.6	41.7	41.5	38.3	39.1	40.6	42.9	41.5	49.3	49.2	1.1%

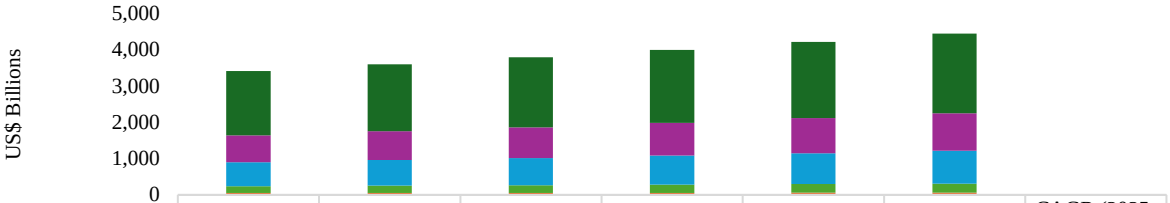
Source: Frost & Sullivan

- **Americas:** Spent USD 1,693.7 billion, the largest share worldwide, with the U.S. accounting for over 90%. Growth in Latin America was limited, though Mexico recorded a 39% YoY increase between the CY2014-CY2024 forecast period, driven by internal security and paramilitary operations.
- **Asia & Oceania:** Spending reached USD 624.7 billion in CY2024, with China contributing USD 317 billion (~50%) toward modernization and naval expansion. Japan, Taiwan, India, and Southeast Asian nations accelerated air, naval, and Intelligence, Surveillance, and Reconnaissance (ISR) procurement in response to maritime disputes.
- **Europe:** Defense budgets rose 6.7% YoY to USD 693.0 billion in CY2030, the fastest growth among regions. Russia's wartime allocation reached USD 150 billion, while NATO members, especially Germany and Poland, expanded procurement pipelines under multi-year commitments.
- **Middle East:** Regional spending totalled USD 179.0 billion in CY2024, led by Israel (+65%, USD 45.2 billion; 8.8% of GDP), and Lebanon (+58%, USD 7.5 billion). In contrast, Iran and fiscally constrained states posted minimal or negative real-term changes.
- **Africa:** Spending remained modest at USD 49.2 billion in CY2024, growing 1.1% between the CY2014-2024 forecast period. North African states such as Algeria and Egypt continued force modernization, while Sub-Saharan Africa remained constrained by inflation and instability, focusing primarily on counterinsurgency and border security.

4.3 Forecasted Global Defense Spending by Region (CY2025-2030)

Global defense spending is projected to grow at a CAGR of 5.6% between CY2025 and CY2030, reaching USD 3,771.5 billion by the end of the period. While absolute growth is evident across all regions, differentiated trajectories reflect the variance in geopolitical risk profiles, fiscal headroom, and modernization imperatives.

Figure 7: Global Defense Spending Forecast by Region, CY2025-CY2030.



	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2025-2030)
Americas	1,768.2	1,846.0	1,927.2	2,012.0	2,100.5	2,193.0	4.4%
Europe	740.8	791.9	846.6	905.0	967.4	1,034.2	6.9%
Asia & Oceania	664.6	707.2	752.4	800.6	851.8	906.3	6.4%
Middle East	189.5	200.7	212.5	225.1	238.4	252.4	5.9%
Africa	50.9	52.6	54.4	56.2	58.2	60.1	3.4%

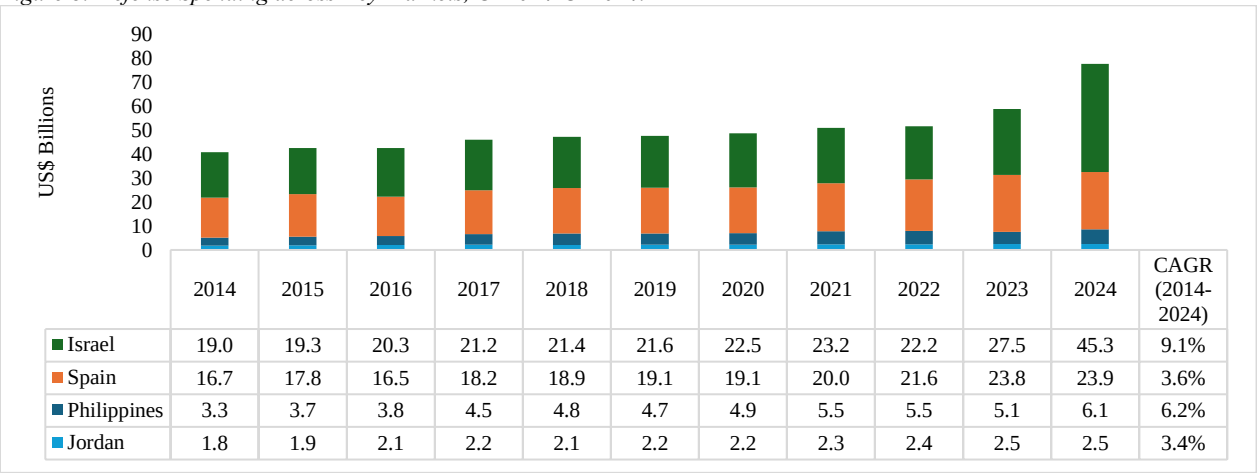
Source: SIPRI, Frost & Sullivan

- **Americas:** Spending will rise from USD 1,768.2 billion to 2,193.0 billion (CAGR 4.4%) between CY2025-CY2030, driven by U.S. investment in deterrence, cyber, and next-gen platforms. Latin America will see modest gains, focused on internal security and maritime awareness.
- **Asia & Oceania:** Expenditure will grow from USD 664.6 billion to 906.3 billion between CY2025-CY2030 (CAGR 6.4%) amid Chinese assertiveness, cross-Strait tensions, and North Korean threats. Key contributors: China, India, Japan, and Southeast Asia, emphasizing air defense, naval expansion, Intelligence, Surveillance, and Reconnaissance (ISR), and unmanned systems.
- **Europe:** Projected to expand from USD 740.8 billion to 1,034.2 billion between CY2025-CY2030 (CAGR 6.9%), the fastest among regions, reflecting post-Ukraine war rearmament. NATO members, especially in Central & Eastern Europe, will accelerate procurement of armored, air defense, and Intelligence, Surveillance, and Reconnaissance (ISR) systems.
- **Middle East:** Forecast to rise from USD 189.5 billion to 252.4 billion between CY2025-CY2030 (CAGR 5.9%), led by Israel and Gulf states, with focus on air defense, counter-unmanned aerial systems (C-UAS), and hardened C2 systems amid persistent conflicts.
- **Africa:** Expected to increase from USD 50.9 billion to 60.1 billion between CY2025-CY2030 (CAGR 3.4%). Growth will remain constrained by economic fragility, though North Africa and parts of Sub-Saharan Africa will invest in surveillance, mobility, and counter insurgency.

4.4 Defense Spending in Key Growth Markets

Defense spending across select strategic markets—Philippines, Jordan, Spain, and Israel—has exhibited varied trajectories in recent years, shaped by divergent security imperatives, economic bandwidth, and operational requirements. Each market presents unique opportunities in modernization, force structure transformation, and technology integration.

Figure 8: Defense Spending across Key Markets, CY2014-CY2024.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR (2014-2024)
Israel	19.0	19.3	20.3	21.2	21.4	21.6	22.5	23.2	22.2	27.5	45.3	9.1%
Spain	16.7	17.8	16.5	18.2	18.9	19.1	19.1	20.0	21.6	23.8	23.9	3.6%
Philippines	3.3	3.7	3.8	4.5	4.8	4.7	4.9	5.5	5.5	5.1	6.1	6.2%
Jordan	1.8	1.9	2.1	2.2	2.1	2.2	2.2	2.3	2.4	2.5	2.5	3.4%

Source: Frost & Sullivan

4.4.1 Philippines

- Defense spending reached USD 6.1 billion in CY2024 (1.3% of GDP) under Horizon 3 of the AFP Modernization Program.
- The focus has shifted from internal security to external territorial defense, driven by maritime disputes with China.
- Key procurements include BrahMos coastal missile systems, UAVs (ScanEagle, Hermes 900), C-295 Intelligence, Surveillance, and Reconnaissance (ISR) aircraft, and underwater domain awareness platforms.
- Strategic cooperation expanded through agreements with the U.S., Japan, and Australia, including the Reciprocal Access Agreement with Japan and joint exercises such as Balikatan.

4.4.2 Jordan

- Defense spending stood at USD 2.5 billion in CY2024 (4.2% of GDP), with priorities on border security, counter-smuggling, and regional readiness.
- Jordan continues to rely heavily on U.S. and NATO support, reinforced by a CY2021 defense cooperation agreement and the opening of a NATO liaison office in Amman in CY2024.
- Procurement has focused on Raven UAVs, night vision systems, and C4Intelligence, Surveillance, and Reconnaissance (ISR) upgrades, alongside Raytheon-led border Intelligence, Surveillance, and Reconnaissance (ISR) integration trials.
- Inventory recapitalization is often based on second-hand or donated platforms, with the Jordan Design and Development Bureau (JODDB) supporting upgrades for light armoured vehicles, through advanced systems remain imported.

4.4.3 Spain

- Defense spending rose to USD 23.9 billion in CY2024 (1.8% of GDP), reflecting NATO and EU readiness commitments after the Ukraine conflict.
- Spending priorities include countering hybrid threats, improving expeditionary capabilities, and supporting NATO operations.
- Ongoing programs include the Future Combat Air System (with France and Germany), a dedicated Space Command (established CY2023), EO/Intelligence, Surveillance, and Reconnaissance (ISR) upgrades, the MALE RPAS program, and coastal naval surveillance suites.
- Spain's industrial base, led by Navantia, Indra, Airbus, and GDELS-Santa Bárbara Sistemas, underpins strong capabilities in shipbuilding, defense electronics, and land systems.
- Future spending is ecpected to emphasize Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (ISR) (C4Intelligence, Surveillance, and Reconnaissance (ISR)), strategic airlift, precision-guided munitions, and space defense infrastructure.

4.4.4 Israel

- Defense spending surged to USD 45.3 billion in CY2024 (4.9% of GDP, +65% year-on-year) due to multi-theatre conflicts involving Gaza, Hezbollah, Yemen, and Iran.
- Israel played a pivotal role in Operation Midnight Hammer (CY2025), conducting pre-emptive strikes on Iranian air defense and nuclear facilities ahead of U.S. operations.
- Procurement has prioritized force protection, precision-guided munitions, Intelligence, Surveillance, and Reconnaissance (ISR) payloads, and loitering munitions, with accelerated deployment of Electro-Optical/Infrared and AI-driven sensor systems.

4.5 Key Drivers for Global Defence Spending

Global defence expenditure is rising across all regions, driven by systemic shocks, evolving threats, and the need to rebuild combat mass. Below are the seven most critical forces shaping spending:

4.5.1 Multipolar Competition and Sustained Conflict

- Global Russia–Ukraine war, Israel's multi-front campaigns, and the CY2025 India–Pakistan conflict underscore a return to high-intensity, state-on-state warfare.
- China's assertiveness in the South China Sea and around Taiwan reflects coercive diplomacy backed by military force.
- Result: Higher spending on Intelligence, Surveillance, and Reconnaissance (ISR), loitering munitions, and multi-sensor Electro-Optical/Infrared suites for information-dominant warfare.

4.5.2 Recalibrated National Defense Strategies

- Budgets have pivot from counterinsurgency to long-term territorial defence, increasing spend on heavy artillery, and resilient Intelligence, Surveillance, and Reconnaissance (ISR) systems which can withstand high intensity conflicy environments.
- NATO's New Force Model and similar doctrines drive investment in AI-enabled sensor fusion, long-range strike capabilities, and high precision targeting systems.

4.5.3 Depleted Inventories and the Rebuilding of Strategic Stockpiles

- The Russia–Ukraine war exposed depleted Western munitions reserves and capacity gaps.
- Nations are procuring long-ange artillery, PGMs, and millile defense systems, prioritizing affordability and mass alongisde next-gen systems.

4.5.4 Software-Defined and Digitally Enabled Warfare

- Intelligence, Surveillance, and Reconnaissance (ISR) data fusion, AI-enabled targeting, and resilient C2 networks now command a dedicated share of budgets.
- Increaisng investment focus on edge computing, network-enabled remotely controlled munitions (e.g. loitering drones), and secure communications.

4.5.5 New Acquisition Models and Institutional Reform

- Agile procurement models replace slow, centralized frameworks.
- Examples: India's Innovations for Defence Excellence (iDEX), U.S. Defense Innovation Unit, UK's Defense and Securuty Accelerator, and NATO's DIANA.
- Emphasis on prototyping, COTS adoption, and dual-use innovation.

4.5.6 Workforce, Readiness, and Societal Resilience

- Personnel shortfalls—especially in high-skill, technical roles—are constraining transformation, prompting reforms to career models, incentives, and training pipelines, alongside higher spend on unit readiness and availability.
- Force planning now embeds societal resilience—civil infrastructure, industrial mobilization capacity, and surge logistics—into NATO-aligned force-generation models.

4.6 Global Defence Modernization – Opportunity Size and Trends

The global defense modernization landscape is evolving in response to mounting geopolitical uncertainty, supply chain disruption, and the urgent need for capability renewal. Between CY2025 and CY2030, global defense spending is expected to grow steadily across all regions, with cumulative annual expenditure projected to rise from USD 2,870 billion to over USD 3,771 billion by CY2030, representing a CAGR of approximately 5.6%. While baseline defense budgets continue to support personnel, operations, and legacy platforms, a growing share is being channeled toward modernization and capability transformation.

4.6.1 Modernization as a Rising Share of Defense Budgets

Modernization is taking a growing share of global defense budgets, signaling a shift from legacy maintenance to next-generation capabilities in Intelligence, Surveillance, and Reconnaissance (ISR), integrated air and missile defense, AI-enabled command, cyber resilience, and precision munitions.

- **United States:** Over USD 315 billion (CY2024), or 45% of its budget, devoted to modernization. Priorities include the B-21 bomber, Columbia-class submarines, NGAD fighter, JADC2 integration, and hypersonic weapons.
- **China:** Estimated spending >USD 300 billion, focused on advanced aerospace, AI-enabled Intelligence, Surveillance, and Reconnaissance (ISR), the Type 003 carrier, and YJ-21 hypersonic missiles to pursue strategic parity with the U.S.
- **Japan:** Nearly doubled its five-year budget to USD 315 billion (CY2023–27), funding F-35s, counterstrike missiles, and space surveillance.
- **Germany:** EUR 100 billion special fund, with F-35A, Eurofighter upgrades, and Arrow 3 missile defense.
- **France:** EUR 413 billion (CY2024–30) under the Loi de Programmation Militaire, focused on FCAS, Aster SAMs, and Scorpion vehicles.
- **Israel:** Despite fiscal limits, continues investing in Iron Dome, David's Sling, loitering munitions, and battlefield digitization.

By CY2030, modernization will account for 30–45% of defense budgets in advanced economies, versus 15–25% in emerging economies, where fiscal and industrial constraints slow capability development.

4.6.2 Key Modernization Trends

- **Proliferation of Unmanned and Counter-Unmanned Aircraft Systems (Counter-UAS)**: Lessons from Ukraine have accelerated the adoption of unmanned systems and loitering munitions, and the development of cost-effective countermeasures. Investment is growing in thermal imaging, radar discrimination, and Directed Energy Weapons (DEWs) to neutralize drone threats. These systems are increasingly used for precision targeting of high-value assets, including command nodes and mobile missile launchers, marking a shift from traditional battlefield engagements to targeted eliminations.
- **Digitalization of Defense Manufacturing:** Across the U.S. and Europe, digitalization is fast becoming a prerequisite for defense industrial participation. Initiatives like the U.S. Defense Industrial Strategy and the European Defence Fund (EDF) increasingly mandate digital engineering, AI-readiness, and secure-by-design software protocols in acquisition. While not yet formalized in India, programs like iDEX and Make-II are moving toward digital-first evaluations in procurement and development partnerships.
- **C4Intelligence, Surveillance, and Reconnaissance (ISR) and Sensor Fusion:** The demand for integrated situational awareness is leading to adoption of battlefield management systems, AI-powered Intelligence, Surveillance, and Reconnaissance (ISR) analytics, and open-standard sensor fusion architectures. Enhanced MANET communications, SATCOM, and AI-enhanced decision aids are seeing rapid deployment.
- **Space and Electromagnetic Warfare:** The weaponization of space, proliferation of EMP-hardened systems, and satellite-based targeting and communications platforms are becoming focal points of modernization budgets. Nations are developing multi-domain awareness and deterrence capabilities leveraging SAR, multispectral sensors, and anti-jamming technologies.
- **Industrial Base Expansion with Tier-2/Tier-3 Participation:** Primes are increasingly relying on risk-sharing partnerships with smaller firms. In regions like India and the EU, this model enables rapid development of low-cost, high-impact subsystems such as electro-optical (EO) sensors, unmanned aerial systems (UAS) components, and passive radar arrays.

4.7 Strategic Trends in Modern Warfare (Defensive Systems)

Modern warfare is shifting from platform-centric to network-centric operations, built on sensor fusion, AI, real-time data, and autonomous systems. Defensive priorities emphasize operational transparency, accelerated decision cycles, and machine-augmented awareness.

4.7.1 Intelligence, Surveillance, and Reconnaissance (ISR)

Intelligence, Surveillance, and Reconnaissance (ISR) underpins modern defense by delivering continuous, multi-domain situational awareness across air, land, sea, space, and cyber. It enables detection, targeting, force protection, and information dominance, making it a central pillar of multi-domain operations (MDO).

Key shifts include:

- **From platforms to ecosystems:** Intelligence, Surveillance, and Reconnaissance (ISR) is evolving from isolated platforms to integrated networks linking satellites, drones, radar, and allied systems. Countries such as the U.S., France, India, Australia, and Japan are building interoperable, service-agnostic Intelligence, Surveillance, and Reconnaissance (ISR) ecosystems.
- **Persistent sensing in contested zones:** Hybrid satellite constellations, stratospheric high altitude pseudo-satellites (HAPS), and autonomous Intelligence, Surveillance, and Reconnaissance (ISR) drones ensure resilience against anti-satellite weapons, jamming, and restricted access.
- **AI, data fusion, and edge computing:** AI-driven object detection, anomaly alerts, and predictive analytics shorten decision timelines. Edge processing reduces latency and bandwidth needs.
- **Resilience under attack:** To counter Global Navigation Satellite System (GNSS) spoofing, C-UAS, and cyber jamming, Intelligence, Surveillance, and Reconnaissance (ISR) nodes now feature redundancy, LPD/frequency-agile comms, and AI-enabled failover logic.
- **Enabler of Multi-Domain Operations:** Intelligence, Surveillance, and Reconnaissance (ISR) guides precision fires, supports cyber/electronic warfare (EW) integration, and sustains mission command in contested environments.

Global examples:

- **U.S.:** JADC2 integration with platforms like TITAN, Global Hawk, and Raytheon's C2 suites.
- **Europe:** FCAS cloud-based Intelligence, Surveillance, and Reconnaissance (ISR) networks linking manned and unmanned systems.
- **India:** Netra AEW&CS, satellite fusion, and private partnerships (e.g., Tata Advanced Systems, Tonbo Imaging).
- **Australia & Japan:** Intelligence, Surveillance, and Reconnaissance (ISR) interoperability through AUKUS and integration with U.S. sensor networks.

4.7.2 Artificial Intelligence

AI is becoming a defining enabler of modern defense, offering faster detection, classification, and tracking than human-led systems. It is embedded across Intelligence, Surveillance, and Reconnaissance (ISR), Command & Control (C2), EW, logistics, and kinetic operations, giving militaries tactical edge and shaping the future balance of power.

Key developments include:

- **Architecture shift:** Transition from human-in-the-loop to human-on-the-loop, where AI manages fusion, prioritization, and low-level decisions (e.g., UAS swarms, threat classification), while humans oversee confirmation and strategy.
- **Multi-domain situational awareness:** AI fuses Intelligence, Surveillance, and Reconnaissance (ISR) streams, including Electro-Optical/Infrared, radar, Signals Intelligence (SIGINT), Electronic Intelligence (ELINT), to detect anomalies, predict intent, and prioritise threats. Examples include maritime awareness in the Indo-Pacific, counter-UAS in the Middle East, and border automation in Central Asia.
- **Operational decision support:** AI enables course-of-action generation, sensor-to-shooter automation, and real-time wargaming, increasingly embedded in mobile command centers for distributed operations.
- **Autonomy:** Expanding across UAV swarms (loitering munitions, battlefield mapping), Unmanned Ground Vehicle – UGV (EOD, route clearance, logistics), and Unmanned Underwater Vehicle – UUV (mine

countermeasures, Intelligence, Surveillance, and Reconnaissance (ISR), ASW). These reduce risk to humans and extend reach into denied environments.

4.7.3 Imaging Technologies

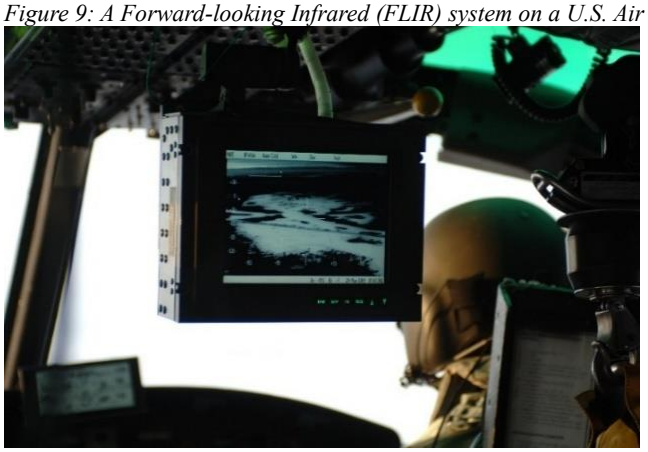
Imaging technologies encompass electro-optical (EO), infrared (IR), multispectral, and hyperspectral systems that capture, process, and interpret visual and thermal data. They enable persistent, high-fidelity, all-weather visibility for Intelligence, Surveillance, and Reconnaissance (ISR), targeting, navigation, and early warning. These include night-vision devices, thermal imagers, airborne sensor pods, stabilized gimbals, and space-based cameras.

The global Electro-Optical/Infrared market is projected to grow from USD 5.9 billion in CY2020 to USD 12.1 billion by CY2030 at CAGR of 7.4%, with Europe showing the fastest growth (~11.5%) and India expanding from USD 507 million to USD 1.3 billion (CAGR 9.9%).

Global Electro-Optical/Infrared is growing faster than the overall defence market because passive, non-emitting sensors are far less vulnerable to jamming than active systems like radar, while providing the high-resolution, target-specific imagery modern precision warfare increasingly depends on.

Leading companies—Teledyne FLIR, L3Harris, Elbit, Rafael, and Leonardo DRS—are driving advances in AI-powered image processing, wide-area surveillance, and edge-enabled sensors. Future breakthroughs are expected in quantum imaging, hyperspectral analysis, and onboard AI, positioning imaging as a force multiplier in multi-domain operations.

Figure 9: A Forward-looking Infrared (FLIR) system on a U.S. Air Force helicopter during search and rescue operation



Source: US Air Force

Key developments include:

- **Multi-spectral fusion:** Synthetic aperture radar (SAR) for all-weather coverage, hyperspectral for concealed target detection, and LIDAR/GMTI for urban mapping and GPS-denied navigation.
- **Miniaturization:** High-performance sensors deployed on micro-UAVs, CubeSats, and autonomous maritime platforms, expanding reach and redundancy.
- **Real-time exploitation:** Onboard AI modules and change-detection algorithms support immediate targeting and decision-making in fast-moving scenarios.
- **Global use cases:** Border surveillance (India–China, South China Sea), counter-insurgency/urban warfare, Arctic monitoring, and space-based missile tracking.
- **Sovereign capability:** Nations like France, South Korea, UAE, and Brazil are investing in domestic satellite imaging programs to secure access, ensure flexibility, and integrate dual-use commercial constellations.

4.7.4 Autonomous Systems

Autonomous systems are now operational across all domains, valued for their ability to extend reach, absorb risk, and sustain operations in denied environments. Modern platforms sense, adapt, and coordinate missions independently, reducing operator burden and accelerating the kill chain.

Figure 10: Concept showing Manned-Unmanned Teaming (MUM-T).

Key developments include:

- **Spectrum of autonomy:** Militaries are moving from operator-controlled UAVs like the MQ-9 Reaper and Bayraktar TB2, toward swarming loitering munitions and early trials of fully autonomous AI-led missions.
- **Multi-domain deployment:** Autonomy is expanding across air (CATS Warrior, Ghost Bat loyal wingmen), land (UGVs for logistics and route clearance), maritime (Autonomous Underwater Vehicles – AUV and Unmanned Surface Vehicles – USVs in the Strait of Hormuz), and space (In-Space Servicing, Assembly, and Manufacturing – ISAM satellite servicing drones).
- **Operational value:** Autonomy allows persistent Intelligence, Surveillance, and Reconnaissance (ISR) and strike in contested zones, reduces troop risk in Chemical, Biological, Radiological, and Nuclear (CBRN) environments, and provides asymmetric mass where low-cost fleets can overwhelm advanced adversaries.
- **C2 and mission autonomy:** Advances in swarming algorithms and mission-level AI are enabling systems to self-assign tasks, adapt to attrition, and shift from surveillance to strike without operator intervention.

4.8 Strategic Trends in Modern Warfare (Offensive Systems)

Offensive warfare is shifting from heavy, logistics-intensive platforms to compact, autonomous, and software-defined strike systems. The drivers are faster kill chains, reduced lifecycle costs, and survivability against modern air defenses and EW threats.

4.8.1 Directed Energy Systems (DES)

DES—including high-energy lasers (HELs), high-power microwaves (HPMs), and radiofrequency (RF) jammers—are redefining both offense and defense. They deliver speed-of-light engagement, near-zero per-shot cost, and effectively unlimited magazines. Adoption is accelerating as drone swarms, missile salvos, and hypersonic threats strain traditional interceptors.

High Power Microwave (HPM) systems provide a non-kinetic alternative by projecting directed electromagnetic energy to disrupt or disable drone electronics at tactically useful ranges. HPM offers scalable effects—from temporary disruption to permanent damage—enables simultaneous engagement of multiple targets, and delivers a very low cost-per-engagement compared with missiles or guns. These attributes reduce logistics burdens and allow sustained defensive operations against massed autonomous threats.

Operationally, HPM weapon systems comprise modulators, amplifiers (klystrons), pulse compressors, antennas on motorized pan-tilt mounts, and an electro-optics targeting subsystem for precise aiming. The architecture supports stationary or mobile ground and naval deployments, with modules coordinated to generate, amplify, and direct

microwave energy for effective neutralization. Integrated with existing sensors and kinetic layers, HPM forms a cost-effective, scalable component of a layered counter-UAS strategy.
Key developments include:

- **Transition drivers:** DES offer a decisive cost-per-shot advantage (dollars vs. hundreds of thousands for missiles), instantaneous engagement against UAVs and hypersonics, and unlimited replenishment via power supply, making them ideal against saturation attacks.
- **Maturation across domains:** Land-based systems like Israel's Iron Beam, Rheinmetall's Skynex, and India's DEW trials are protecting bases and cities; the U.S. Navy's HELIOS is being integrated on destroyers; and airborne DEW concepts target ballistic missiles during boost phase.
- **Operational roles:** DES are evolving into layered kill-web components—counter-UAS in urban zones, missile-defense augmentation to thin salvos, and HPM electronic attack to disable sensors and comms in escalation-sensitive environments.
- **Market growth:** The global DES market will rise from USD 504 million in CY2025 to USD 5.6 billion in CY2030 (CAGR >60%). Europe will scale from USD 184 million to USD 1.2 billion, and India from USD 58 million (CY2026) to nearly USD 300 million (CY2030), underscoring demand and urgency.

Figure 11: Applications for Directed Energy Systems Across Operational Theatres.

Source: DoD HPM DEW Effects Panel, Frost & Sullivan

4.8.2 Autonomous Loitering Munitions, and Missiles

Autonomous loitering munitions are small, expendable UAV-borne warheads that loiter over a target area, autonomously navigate and search, then dive to strike a positively identified target—typically with a human-in/on-the-loop for consent; they integrate compact fixed/folding-wing airframes and electric/hybrid propulsion with Electro-Optical/Infrared (sometimes RF/Millimeter Wave) seekers, GNSS/INS guidance with geofenced fail-safes/self-destruct, secure datalinks to portable controllers, and mission-tailored high explosive or shaped-charge warheads, and are usually tube- or vehicle-launched.

Key developments include:

- **Drivers of adoption:** Loitering munitions and autonomous missiles mitigate the vulnerabilities of expensive fighters—reducing pilot risk, enabling persistent Intelligence, Surveillance, and Reconnaissance (ISR)-strike, and delivering cost-effective saturation in denied airspace.
- **Rise of loitering munitions:** Systems such as the Switchblade, Hero, Lancet, Harop, SkyStriker, and India's ALS-50 offer autonomous navigation, surveillance, and precision strike. Proven in Nagorno-Karabakh, Ukraine, Gaza, and Libya, they deliver overmatch against armor, radars, and supply nodes.

- **High-speed autonomous missiles:** AI-enabled cruise and hypersonic weapons (e.g., Russia's Avangard, China's DF-ZF, India's HSTDV, U.S. ARRW, China's YJ-21) promise rapid penetration, re-targeting in flight, and multi-vector strike coordination.
- **Integration with manned platforms:** Loyal wingman concepts—Australia's Loyal Wingman, India's CATS Warrior, U.S. Skyborg, Europe's FCAS remote carriers—pair manned fighters with autonomous assets for scouting, jamming, and first-strike roles.
- **Industrial and geopolitical impact:** Nations such as Iran, Türkiye, and Israel are scaling indigenous production for exports; Eastern Europe and Indo-Pacific states are investing heavily. OEMs are modularizing payloads, hardening navigation, and enabling interoperability across platforms.

Figure 12: American Long-Range Hypersonic Weapon being deployed at the Cape Canaveral Space Force Station.

Source: US Army

4.9 Global Regulations in Defense Trade

The global defense trade ecosystem operates under a complex lattice of international regulations, bilateral treaties, and national export control regimes. These frameworks, designed to balance national security, geopolitical stability, and non-proliferation, play a decisive role in shaping the flow of military hardware, subsystems, and dual-use technologies across borders.

Among these regulations, the United States International Traffic in Arms Regulations (ITAR) has emerged as one of the most far-reaching and commercially influential frameworks.

4.9.1 International Traffic in Arms Regulation

The International Traffic in Arms Regulations (ITAR) remains the most influential and extraterritorial of all defense export control systems.

- **Administered by:** U.S. Department of State, Directorate of Defense Trade Controls (DDTC)
- **Applies to:** All items on the U.S. Munitions List (USML), including weapons, electronics, military-grade optics, UAVs, and many components and subsystems critical to global supply chains.

Key Characteristics:

- **Extraterritorial Reach:** Any product or system containing U.S.-origin defense components—even if manufactured or assembled abroad—falls under ITAR purview. This includes software, subcomponents, and technical data.
- **Licensing and End-Use Controls:** Exporters must obtain approval for every transaction, specifying the end-user and application. Unauthorized re-transfer or deviation from licensed use can result in severe penalties.
- **Partner Restrictions:** ITAR prohibits exports to embargoed nations and imposes stringent limitations on certain countries (e.g., China, Iran, North Korea, Russia), constraining multi-country supply chains and joint ventures.

Strategic Implications:

- **Market Access Constraints:** Defense exporters operating within U.S.-linked supply chains often face restrictions entering certain global markets disfavored by U.S. foreign policy. As a result, several OEMs have adopted ITAR-free design strategies to preserve access to non-aligned regions, ensuring platforms remain commercially viable across a wider set of geographies.
- **Partner Vetting Complexity:** Companies engaged in multinational programs must conduct meticulous vetting of their collaborators, sub-suppliers, and investors for potential ITAR exposure. This has led to the formalization of "ITAR-free" program mandates in several countries, especially in Europe and Asia, to avoid deal-breaking compliance hurdles at late stages of development or export negotiation.
- **Innovation Friction:** Concerns over licensing delays, export uncertainty, and restrictions on technical collaboration have driven a wave of indigenous development efforts aimed at full autonomy. Entities like France's Thales and Dassault, Israel's IAI, and India's DRDO have proactively pursued ITAR-free development of mission-critical systems, such as Electro-Optical/Infrared payloads, data links, missile seekers, and avionics, where even small U.S.-origin components could trigger regulatory entanglements.

4.9.2 Missile Technology Control Regime

The Missile Technology Control Regime (MTCR) is a voluntary, consensus-based framework established to limit the spread of missile systems and unmanned delivery platforms capable of carrying weapons of mass destruction (nuclear, chemical, and biological).

- Established: CY1987; 35 members
- Scope: The scope is divided into two categories,
  Category I: Complete delivery systems (e.g., cruise missiles, MALE/HALE UAVs) capable of carrying a 500 kg payload over 300 km. Exports are presumed to be denied.
  Category II: Components, subassemblies, and systems with shorter range or lighter payload—exportable subject to national discretion and end-use validation.

Strategic Implications:

- Directly influences loitering munition and long-range drone exports, especially to non-MTCR countries.
- India's accession to MTCR in CY2016 enabled more latitude in developing systems like the Shaurya missile and long-range Intelligence, Surveillance, and Reconnaissance (ISR) drones, while opening export markets (e.g., Philippines, Armenia).
- Restricts co-development with certain partners, limiting global diffusion of high-speed, precision-strike capabilities.

4.9.3 Wassenaar Arrangement

The Wassenaar Arrangement governs exports of conventional arms and dual-use technologies with potential military applications.

- **Participants:** 42 countries, including major defense exporters (U.S., EU states, Japan, South Korea, India)
- **Focus areas:** Radars, Electro-Optical/Infrared sensors, cryptographic systems, AI-enabled tools, semiconductor-grade electronics, Intelligence, Surveillance, and Reconnaissance (ISR) platform

Strategic Impact:

- Wassenaar's controls target commercial-off-the-shelf (COTS) components that can be weaponized or integrated into defense platforms (e.g., image processors, RF modules, signal processing chips).
- Growing emphasis on emerging technologies, e.g., AI-enabled target recognition, quantum cryptography, and cyber-intelligence platforms, indicating a move beyond hardware to include algorithms, software libraries, and training datasets.

4.9.4 EU Common Position and National Controls

Europe operates under the EU Common Position on Arms Exports, which requires:

- Assessment of end-use and human rights implications;
- Export denial if there is a "clear risk" of misuse or diversion;
- Coordination among member states to avoid undercutting embargoed markets.

This results in divergent interpretations, e.g., Germany often applies stricter criteria than France or Italy, impacting joint programs like Eurodrone or FCAS.

National controls also persist:

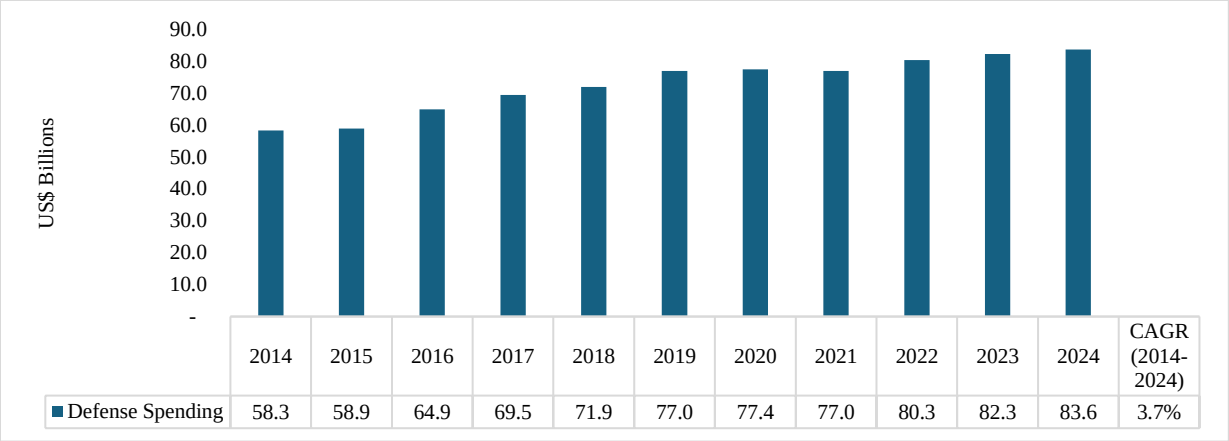
- **France:** Maintains strong national discretion in defense exports, balancing sovereign industry support and geopolitical interests.
- **Germany:** Recently moved toward liberalization but remains risk-averse in conflict zones.
- **India's SCOMET list:** Now harmonized with MTCR/Wassenaar, increasingly used to regulate UAVs, radars, propulsion tech, and dual-use software exports.

5 India Defence and Security

5.1 India's Defense Spending (FY2014-24)

India's defense budget has demonstrated steady, if incremental, year-on-year growth over the past decade, reflecting both inflationary adjustments and a broader shift toward modernization, strategic deterrence, and indigenization. In FY2014, defense spending stood at USD 58.3 billion, and by FY2024 it had risen to USD 83.6 billion, marking a 3.7% increase over the 10-year period.

Figure 13: India Defense Spending, FY2014-2024.



	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR (2014-2024)
Defense Spending	58.3	58.9	64.9	69.5	71.9	77.0	77.4	77.0	80.3	82.3	83.6	3.7%

Source: Frost & Sullivan

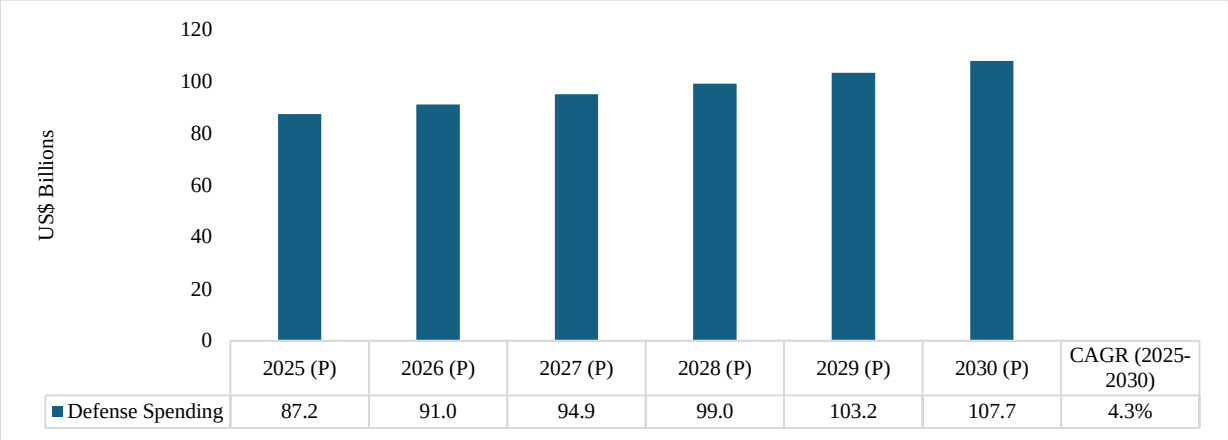
While annual growth rates have ranged between 2.5% and 8%, key inflection points include:

- **Structural Budget Uplift Post-FY2016:** Between FY2016 and FY2018, India's annual defense allocations increased sharply, supported by revised fiscal frameworks and heightened regional threat perception following the CY2016 Uri attack and CY2017 Doklam standoff. Spending rose from USD 64.9 billion in FY2016 to USD 69.5 billion in FY2018, at a CAGR of 3.5%, marking the most rapid two-year increase since 2010.
- **Plateau During COVID-19 and Post-Balakot Readjustment (CY2019–CY2021):** Despite the CY2019 Balakot airstrikes and China's growing assertiveness in Ladakh, India's defense budget growth decelerated between FY2019 and FY2021, largely due to fiscal tightening amid the COVID-19 pandemic and slower capital outlay disbursements. Spending stabilized between USD 77.0 billion and USD 77.4 billion, with a slight decline marginal real-term decline when adjusted for inflation.
- **Capital Reinvestment Phase: FY2022–FY2024:** From FY2022 onward, India resumed steady budgetary growth, climbing to USD 80.3 billion in FY2022, USD 82.3 billion in FY2023, and reaching USD 83.6 billion in FY2024. This renewed upward trajectory was further accelerated by the FY2020 Galwan Valley clash with China, prompting new capital allocations toward border infrastructure, Intelligence, Surveillance, and Reconnaissance (ISR) capabilities, and high-altitude readiness. Capital spending as a share of the defense budget crossed 30%, reflecting India's long-term commitment to modernizing platforms and procurement frameworks.

5.2 India's Defense Spending (FY2025-30)

India's defense spending is projected to increase steadily from USD 87.2 billion in FY2025 to USD 107.7 billion by FY2030, reflecting a compound annual growth rate (CAGR) of 4.3% over the forecast period. For FY2025–26, the Ministry of Defence has allocated ₹6,81,210.27 crore (≈ USD 78.9 billion) to defense, of which ₹1,92,388 crore (≈USD 22.3 billion) is earmarked as capital outlay. This represents a continuation of India's gradual but deliberate pivot toward capability-building and modernization.

Figure 14: India Defense Spending Forecast, FY2025-FY2030

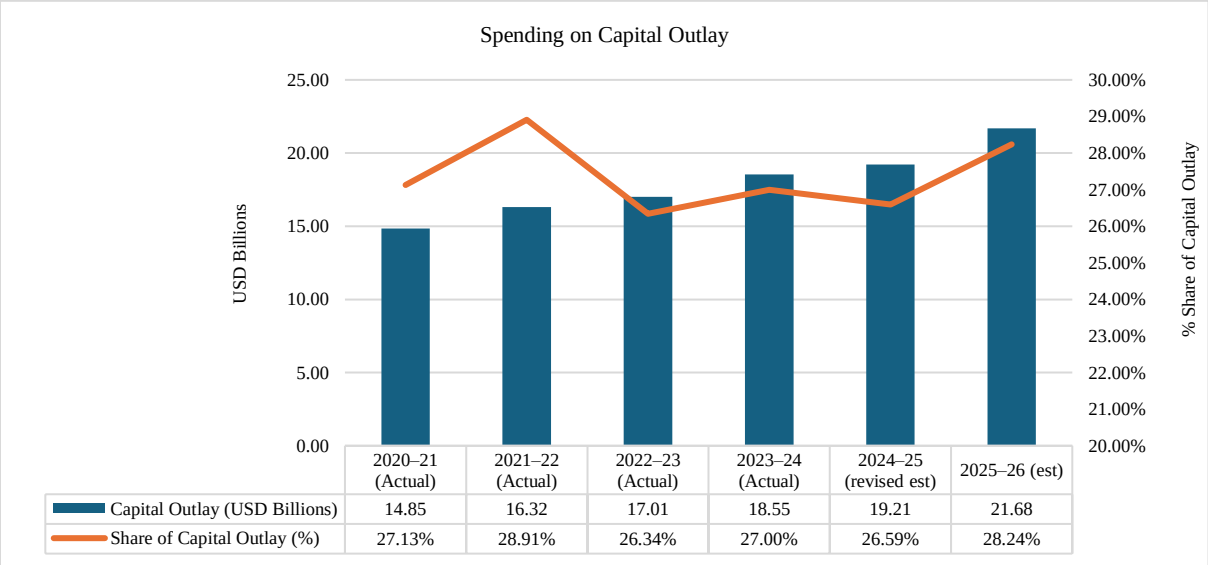


	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2025-2030)
Defense Spending	87.2	91.0	94.9	99.0	103.2	107.7	4.3%

Source: Frost & Sullivan

India's defence capital expenditure has shown steady strengthening as the government prioritises long-term modernisation and indigenisation. The capital outlay has stabilised at a healthy 28–30% share of total defence spending, with sustained year-on-year increases from FY2022 to FY2025. The FY2025 and projected FY2026 budgets continue this positive momentum, allocating larger capital resources for aircraft, naval platforms, advanced sensors, and joint-service modernisation programmes. This upward trend reflects India's commitment to accelerating capability upgrades, supporting domestic manufacturing under "Aatmanirbhar Bharat," and ensuring that capital spending remains a core pillar of its defence investment strategy.

Figure 15: India Defense Capital Spend Relative to Overall Budget Expenditure



	2020–21 (Actual)	2021–22 (Actual)	2022–23 (Actual)	2023–24 (Actual)	2024–25 (revised est)	2025–26 (est)
Capital Outlay (USD Billions)	14.85	16.32	17.01	18.55	19.21	21.68
Share of Capital Outlay (%)	27.13%	28.91%	26.34%	27.00%	26.59%	28.24%

Source: Frost & Sullivan

5.3 India's Defence Budgets & Expenditure across the Indian Army, Navy, & Airforce (FY2023-FY2024)

India's defense expenditure in FY2024 reflects a traditional structure weighted heavily toward personnel costs and land-based operations. However, the composition also reveals continued commitment to modernization via capital outlays, particularly for the tri-services.

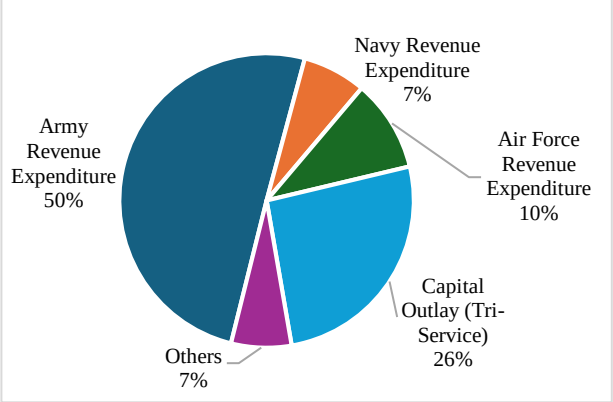
5.3.1 Service-wise Revenue and Capital Allocation (FY2023-FY2024)

In FY 2024, the Indian Army absorbed the lion's share of the revenue expenditure:

- **Army Revenue Expenditure:** USD 37.5 billion, reflecting the Army's expansive personnel base and widespread territorial responsibilities.
- **Navy Revenue Expenditure:** USD 5.2 billion, indicating modest growth, aligned with the Navy's modernization of blue-water capabilities.
- **Air Force Revenue Expenditure:** USD 7.5 billion, focused largely on operational and maintenance support for high-value airborne platforms.
- **Capital Outlay (Tri-services):** USD 19.4 billion, demonstrating the government's push for capability enhancement across all branches.
- **Other Expenditures** (including Joint Commands, DRDO, etc.): USD 4.9 billion.

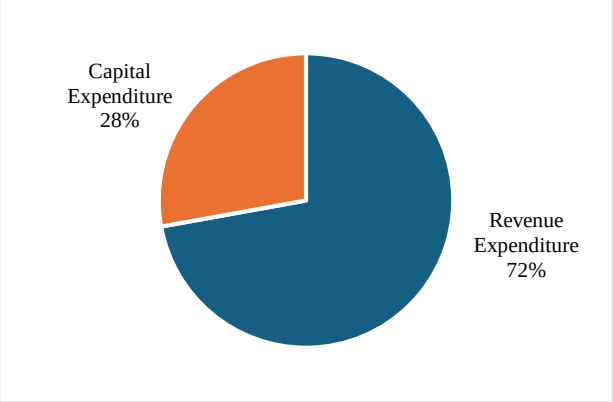
This breakdown highlights the continued dominance of the Army in expenditure allocation, while also showing increasing capital investments that align with India's Make-in-India and indigenization drive.

Figure 16: Service-wise Revenue Expenditure and Capital Allocation FY2023-FY2024.



Source: Frost & Sullivan

Figure 17: Total Revenue Expenditure and Capital Expenditure of Indian Defense Budget, FY2023-FY2024.

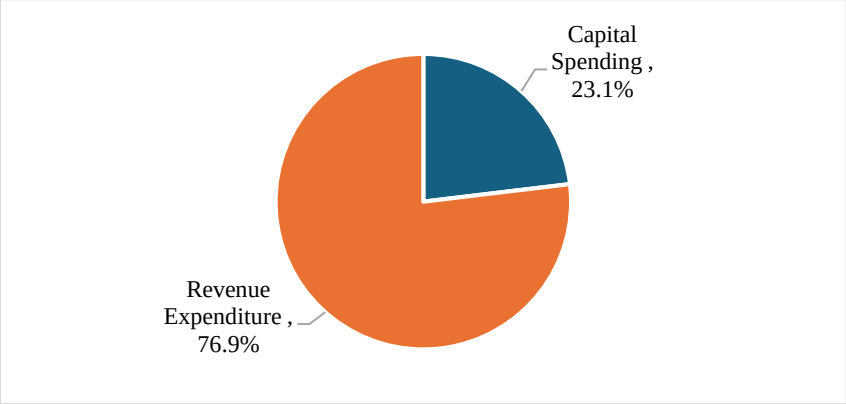


Source: PRS Legislative Research, Frost & Sullivan

5.3.2 Share of Capital versus Revenue Expenditure (FY2023-FY2024)

India's defense expenditure in FY2024 remains overwhelmingly skewed toward revenue expenditure, which accounts for 76.9% of total outlays, compared to just 23.1% for capital spending.

Figure 18: Share of Capital versus Revenue Expenditure FY2023-FY2024



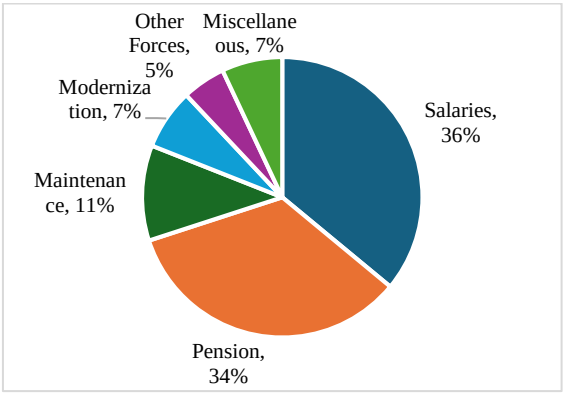
Source: Frost & Sullivan

5.3.3 Budgetary Allocation for the Indian Army (FY2023-FY2024)

The Indian Army continues to command the largest share of the defense budget in absolute terms—approximately USD 42.2 billion in FY2024 . However, nearly 70% of this outlay is absorbed by revenue expenditure, primarily salaries and pensions, leaving limited fiscal headroom for modernization. Excluding defense pensions, the revised estimates of Indian Army's budget amounts to approximately USD 27.7 billion in FY2024.

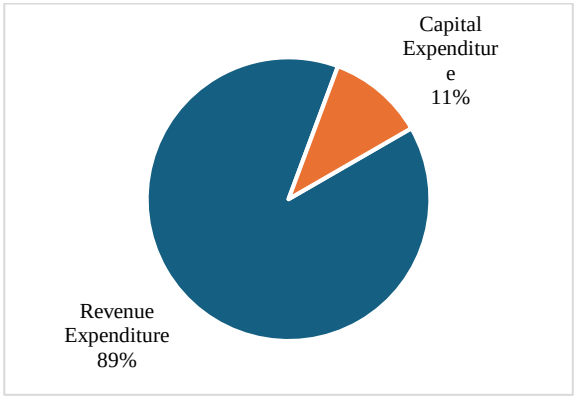
- Capital expenditure accounts for just 8% of the Army's budget, despite urgent recapitalization needs.
- Army's modernization share has shrunk to 20% of the total defense modernization budget, down from earlier benchmarks.
- Only 15% of Army equipment is classified as modern, far below the 30% target outlined in force transformation objectives FY2024-25.

Figure 19: Budget Composition of Indian Army, FY2023-FY2024 Revised Estimates



Sources: PRS Legislative Research, Frost & Sullivan

Figure 20: Revenue and Capital Expenditure of Indian Army, FY2023-FY2024



Sources: PRS Legislative Research, Frost & Sullivan

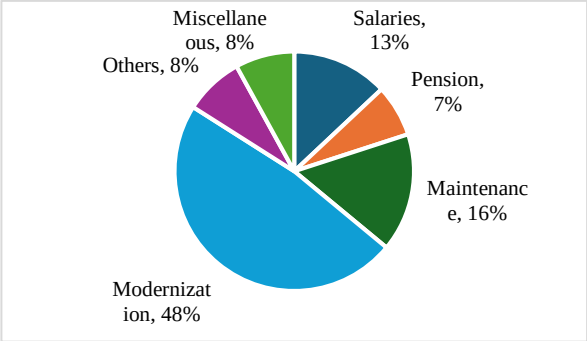
5.3.4 Budgetary Allocation for the Indian Navy

The Indian Navy's FY2024 budget stands at USD 12.1 billion, with a notably higher capital allocation share compared to the other services. Roughly 48% of the Navy's budget is dedicated to modernization, reflecting its strategic pivot toward maritime deterrence and fleet expansion.

- The Navy is targeting a 175-platform force structure by FY2035, with 43 vessels currently under construction.
- It absorbs nearly 37% of India's total defense modernization budget, underscoring its growing strategic weight.
- Capital programs underway include:
  - Next-generation destroyers and stealth frigates
  - Conventional and nuclear-powered submarines

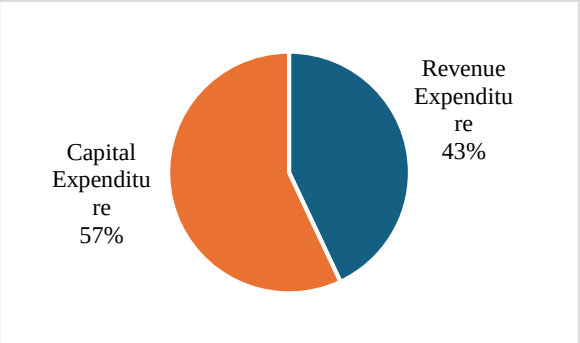
- Aircraft carriers and naval UAVs

Figure 21: Budget Composition of Indian Navy, FY2023-FY2024 Revised Estimate.



Source: PRS Legislative Research, Frost & Sullivan

Figure 22: Split of Revenue Expenditure and Capital Expenditure, FY2023-FY2024



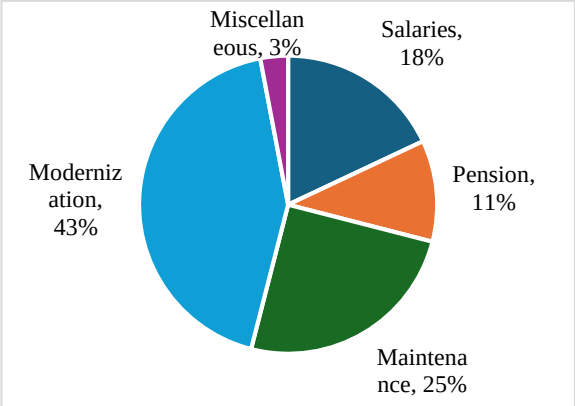
Source: PRS Legislative Research, Frost & Sullivan

5.3.5 Budgetary Allocation for the Indian Air Force

The Indian Air Force (IAF) has a FY2024 budgetary allocation of USD 15.4 billion, with 43% of the budget directed toward modernization, the second-highest among the services.

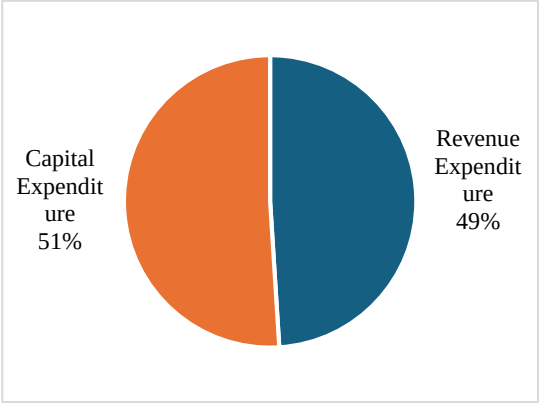
- The IAF continues to face acute platform shortfalls, with only 31 active fighter squadrons against a sanctioned strength of 42.
- Combat fleet strength is expected to decline further as Mig-21, Jaguar, and Mirage 2000 platforms near the end of service life.
- The IAF's key modernization thrusts include:
  - Induction of the HAL Tejas (LCA)
  - Procurement of mid-air refuellers and AWACS platforms
  - Development of 5th-generation AMCA fighters

Figure 23: Budget Composition of Indian Air Force, FY2023-24 Revised Estimates.



Source: PRS Legislative Research, Frost & Sullivan

Figure 24: Split of Revenue Expenditure and Capital Expenditure, FY2023-FY2024.



Source: PRS Legislative Research, Frost & Sullivan

5.4 Growth Drivers of India's Defense Spending

India's defense spending trajectory is underpinned by both enduring geopolitical challenges and structural policy reforms aimed at fostering industrial autonomy, operational modernization, and global positioning. The following key growth drivers outline the foundational pillars influencing future expenditure.

5.4.1 Indian Defense Modernization Programs

India's ongoing modernization drive, centered around capability overhaul and doctrinal shift, is a primary catalyst for increased capital spending. The transformation spans across domains:

- **Combat platform renewal:** Replacement of legacy tanks (T-72), ICVs (BMP-1/2), aging fighter squadrons (Mig-21, Jaguar, Mirage 2000), and naval surface assets.
- **Emerging domains:** Investment in cyber warfare, space-based Intelligence, Surveillance, and Reconnaissance (ISR), integrated command systems, and multi-domain operations.
- **Force restructuring:** The move toward Theatre Commands and Integrated Battle Groups (IBGs) aims to streamline jointness and elevate operational readiness across regions.

5.4.2 Aatmanirbhar Bharat: Prioritizing Domestic Production

The government's flagship Aatmanirbhar Bharat (Self-Reliant India) vision has triggered a structural reorientation of India's defense procurement strategy. Defense is now treated as a strategic industrial sector, with policies designed to:

- Mandate domestic value addition in procurement
- Elevate Indian firms from build-to-print vendors to design-own-integrate producers
- Incentivize public-private partnerships, especially in electronics, optics, loitering munitions, and AI-enabled systems

Capital allocations are increasingly skewed toward indigenous suppliers, with the Ministry of Defence (MoD) earmarking over 75% of FY2023–FY2024 capital procurement for domestic vendors.

5.4.3 Government Initiatives to Promote Defense Production

India's defense industrial push is anchored in reforms, funding support, and policies that drive self-reliance, innovation, and private sector participation.

A landmark step was the creation of the Chief of Defence Staff (CDS) and the Department of Military Affairs (DMA) in FY2019, streamlining coordination and accelerating indigenization. The DMA has since issued five positive indigenisation lists covering 500+ items, including missiles, aircraft, helicopters, ships, and advanced munitions, ensuring future procurement is domestically sourced.

5.4.3.1 Revised Procurement Priorities under DAP FY2020

The Defence Acquisition Procedure (DAP) has restructured acquisition categories to elevate Indian firms as system integrators, while progressively restricting foreign OEMs to roles of equity partners, tech providers, or subcontractors.

Key features include:

- **Indigenous Content (IC) Mandates:** The top four procurement categories—Buy (Indian-IDDM), Buy (Indian), Buy and Make (Indian), and Buy (Global – Manufacture in India)—now carry minimum IC thresholds of 50–60%, with the Buy (IDDM) category requiring Indian design ownership and at least 30% indigenous content.
- **FDI-Linked Execution Rights:** Foreign ownership under automatic approval is capped at 49% for IDDM and up to 74% for other categories, ensuring Indian strategic control while permitting technology access.

5.4.3.2 Make & Innovation Schemes

India has consolidated its industry-led prototyping and R&D initiatives into three pathways under the 'Make' umbrella:

Table 2: Make and Innovation Categories

Category	Features	FDI Cap
Make-I	70% govt-funded R&D, capped at INR 2.5B per agency	49%
Make-II	Self-funded prototypes for IC-based procurement	49%
Make-III	Import substitution for in-service equipment	74%

5.4.3.3 Offsets Reimagined

India's Offset Policy 2.0, embedded in DAP 2020, moves away from basic component offsets toward long-term tech transfer and platform-centric industrial participation:

- Offset banking has been eliminated to reduce transactional arbitrage; obligations must now directly link to program execution.
- Offsets can now be discharged via investment in Indian R&D, export facilitation, and dual-use tech transfer (e.g., hypersonics, DEWs).
- Major deals like the Rafale offset program (INR 59,000 crore contract with ~50% offset) now serve as templates for future joint production mandates.

5.4.3.4 Industrial Enablers and Infrastructure

- **Defence Industrial Corridors (UP and TN):** Anchor clusters to co-locate manufacturing, testing, and logistics with investor incentives and land grants.
- **SPMs (Special Purpose Mechanisms):** Enable fast-track procurement for critical needs via G2G or industry-specific pathways.
- **Defence Investor Cell:** Single-window clearance and grievance redressal for private and foreign investors.
- **Liberalized FDI Norms:** Since FY2014, FDI caps have been progressively relaxed from 26% to 49%, and subsequently to 74% automatic for most sectors. This has driven inflows of INR 57 billion (~USD 609 million) by FY 2024.

5.4.3.5 Regulatory Tailwinds for Domestic Manufacturing

The MOD is actively pushing for localization in DPSU supply chains and expanding private access to government-run testing facilities. In parallel, procurement regulations now favor:

- Indigenous design ownership and minimum Indian content thresholds
- Lifecycle support from Indian vendors for imported systems
- Tier-2 and Tier-3 private vendor development via partnering contracts and risk-sharing mechanisms

5.4.3.6 Reducing Import Dependence and Promoting Exports

India’s twin focus on import substitution and export promotion has accelerated post-FY2020, driven by both strategic vulnerabilities and global opportunity:

- **Negative Import Lists:** Over 100 items across artillery, UAVs, sensors, and munitions are not embargoed for foreign purchase.
- **Positive Indigenization Lists:** Provides long-term visibility to industry on future procurement priorities. The Department of Military Affairs (DMA) has released five positive indgenisation lists of over 500 items, which will be manufactured within India.
- **Export growth:** India's defense exports crossed INR 21,000 billion (~USD 2.5 billion) in FY2023–FY2024, a 30x increase over a decade and has exported defence equipment to over 100 countries, with the USA, France, and Armenia emerging as the top buyers. Recent flagship export deals include:
    - BrahMos supersonic cruise missile system sold to the Philippines in a USD 375 million contract—the first major export of an Indian strategic weapon system.
    - ALH Dhruv helicopters and offshore patrol vessels delivered to Mauritius, Maldives, and Seychelles.
    - The Dornier 228 light transport aircraft and Chetak helicopters, exported to countries across Southeast Asia and Africa, strengthening India’s presence in non-traditional defense markets.
    - Radar systems and naval components exported to Armenia, Myanmar, and several Southeast Asian and African partners.
    - In CY2014, India’s shipyards – GRSE and Goa Shipyard – exported an Offshore Patrol Vessel (CGS Barracuda) to Mauritius. In February CY2025, GRSE secured a new contract for the ship's refit, which includes routine overhaul, services, and critical component replacement.
    - India's Tata Advanced Systems Limited (TASL) won a contract with the Moroccan government to produce and deliver the Wheeled Armoured Platform (WhAP) 8x8 to the Royal Moroccan Army in FY2024.

Key export focus areas include:

- Loitering munitions and counter-drone systems
- Electro-optic payloads and radars
- Naval platforms and maintenance services
- Simulator, C4Intelligence, Surveillance, and Reconnaissance (ISR), and drone subsystems

India's aim to become a net defense exporter by the early FY2030s is supported by G2G frameworks, line-of-credit-based sales, and policy backing via DGDE and Indian Defence Attachés abroad.

5.4.4 Strategic Military Developments – China, Pakistan, and Beyond

Regional security dynamics remain the most acute and persistent driver of defense spending:

China Factor:

- Continued standoff across the Line of Actual Control (LAC) despite disengagement agreements.
- China's naval expansion in the Indian Ocean Region and dual-use port investments in Pakistan, Sri Lanka, and East Africa.
- Military infrastructure race in the Himalayas, forcing India to expand dual-use tunnels, airstrips, and Intelligence, Surveillance, and Reconnaissance (ISR) coverage.
- China-Pakistan military alignment, including joint exercises, weapons transfers, and UAV cooperation.

India–Pakistan Flashpoints:

- Although cross-LoC exchanges have reduced post-FY2021 ceasefire reaffirmation, Pakistan remains a conventional and sub-conventional threat vector.
- Emphasis on counter-terror operations, airbase defense, and border surveillance continues.

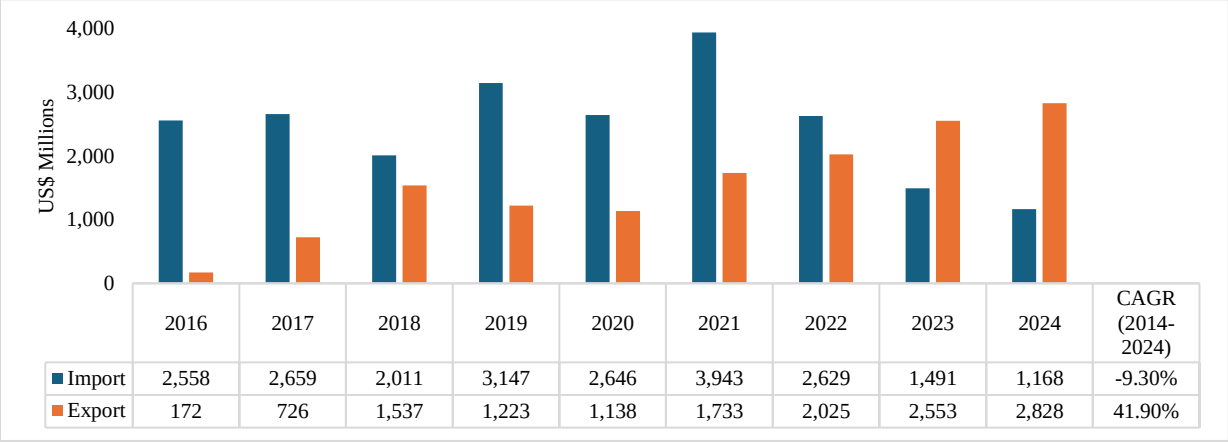
Other developments:

- Instability in Bangladesh and Myanmar adds complexity to India's eastern flank.
- Rising Indo-Pacific cooperation (e.g., QUAD, Indo-French naval ties) compels increased maritime and aerospace investment.

5.5 India's Defense Exports and Imports

India's defence trade profile has undergone a significant transformation over the last decade, reflecting the dual priorities of import substitution and export growth as part of the broader national ambition for defense self-reliance.

Figure 25: Total value of defence goods imported and exported by India, FY 2016-17 to FY2024-25



	2016	2017	2018	2019	2020	2021	2022	2023	2024	CAGR (2014-2024)
Import	2,558	2,659	2,011	3,147	2,646	3,943	2,629	1,491	1,168	-9.30%
Export	172	726	1,537	1,223	1,138	1,733	2,025	2,553	2,828	41.90%

Source: SIPRI Arms Transfer Database

5.5.1 Defense Import Trends

India's defence imports, long among the highest globally, have shown a marked decline from USD 3,943 million in FY2021 to USD 1,168 million in FY2024, reflecting a 71% drop over three years. This trend underscores several key structural and policy shifts:

- **Local Indigenization and Procurement Reforms:** Through schemes such as Buy (Indian-IDDM), the Defence Acquisition Procedure (DAP) has deprioritized direct imports in favor of domestic system integration.
- **Export Control Streamlining and Dual-Use Substitution:** Many formerly imported dual-use systems are now sourced domestically via innovation programs like iDEX and DRDO's Technology Development Fund (TDF).

- **Russia Dependency Mitigation:** With the geopolitical volatility following the Russia–Ukraine conflict and related logistical and sanctions risks, India has actively reduced dependency on legacy Russian imports.

5.5.2 Defense Export Surge and Strategic Reorientation

India's defence exports have witnessed 16x growth over the last eight years, rising from USD 172 million in FY2016 to USD 2,828 million in FY2024, with the private sector now outpacing DPSUs in export value. Key enablers include:

- **Policy Reforms:** Relaxation of licensing, the establishment of the Defence Export Authorization System, and reorientation of the offset policy (DAP 2020) to emphasize technology and platform-level exports.
- **Private Sector Leadership:** Firms such as Paras Defence, Bharat Forge, Larsen & Toubro, and Tonbo Imaging have emerged as leading exporters, particularly in electro-optics, armored systems, missile subsystems, and marine platforms.
- **Strategic Export Targets:** The GoI aims to achieve USD 5 billion in annual exports by FY2025, as part of a broader USD 25 billion defence production target.

5.5.3 Export Destinations and Deal Highlights

The target countries for exports include South Africa, Thailand, Azerbaijan, Singapore, Sweden, Seychelles, Indonesia, Estonia, the Philippines, Guinea, Lebanon, Qatar, Iraq, Uruguay, Ecuador, Japan, Egypt, the United States, Finland, Australia, France, Germany, the Netherlands, and Israel.

Recent exports to other countries:

Table 3: Key Defense Export Programs

Country	Budget	System Type	Details
Philippines	USD 374 million	Missile System	BrahMos shore-based anti-ship missile system (FY2022)
Vietnam	USD 100 million (Line of Credit)	Naval Platform	12 High Speed Guard Boats; lightweight torpedoes exported
Myanmar	USD 37.9 million	Naval Platform	Export of lightweight torpedoes (FY2017)
Malaysia	Not disclosed	Avionics	Export of Avionics for Sukhoi Su-30MKM
Singapore	USD 123,780	Radar Components	Export of radar components
United Arab Emirates	USD 21 million	Protection Equipment & Artillery	Mine-protected vehicles, helmets, soft armour, over-vests, helicopter protection kits; artillery gun components (FY2017)
Germany	Not disclosed	Protection Equipment	Bomb suppression blankets, helmets, cartridges, soft armour panels
Armenia	USD 265 million	Radar & Artillery Systems	Weapon locating radar systems; 4 Pinaka batteries and other equipment (FY2023)
Mauritius	USD 27 million	Naval Platforms	1 Fast Patrol Vessel, and 11 Fast Incercepter Boats exported

Source: Frost & Sullivan Analysis, Ministry of Defence, India

5.6 Indian Defence Industry Policy and Regulation Updates

Since FY2020, India's defence sector has undergone major policy overhauls aimed at indigenisation, procurement reform, and private/foreign investment. These changes mark a decisive break from legacy frameworks and are reshaping the industry landscape.

- **Defence Acquisition Procedure (DAP) 2020:** Introduced in October FY2020, DAP streamlined capital acquisitions, prioritised Buy Indian (IDDM), and introduced the "Buy (Global–Manufacture in India)" category to attract foreign OEMs to set up local production. Simplified "Make" provisions encourage domestic R&D, while offsets were removed for government-to-government and single-vendor deals to expedite urgent procurement. Early results include large-scale contracts such as the Army's INR 7,000 crore ATAGS order under the Buy Indian–IDDM route.

Table 4: Prioritised Defence Procurement Categories

Procurement Category	Indigenous Content (IC) Requirement	Eligible Vendors	Maximum FDI cap allowed under automatic route
Buy (Indian-IDDM)	Indigenous Design & IC of ≥ 50%	Indian firm	49%
Buy (Indian)	50% IC if Indigenous Design; Otherwise, IC of ≥ 60%	Indian firm	74%
Buy and Make (Indian)	≥50% IC in Make Portion	Indian firm	74%
Buy (Global-Manufacture in India)	IC of ≥50%	Foreign firm	74%
Buy (Global)	Foreign Vendor- NIL Indian Vendor ≥30% IC	Foreign/Indian firm	NA (Foreign); 74% (Indian)

Source: Ministry of Defence, India, Defence Procurement Category, FDI Capital Procedure FY2020

- **Positive Indigenisation Lists (Import Bans):** Since August FY2020, the Ministry of Defence has issued five lists covering 600+ items—from fighter aircraft, UAVs, and artillery guns to spares and line-replacement units. These legally enforce procurement only from domestic sources by set cut-off dates (FY2020–FY2027). DPSUs have also issued parallel lists, with the 5th list in FY2024 covering 346 items. The bans have already halted imports of key platforms (e.g., missiles, helicopters) and spurred joint ventures, new production lines, and technology transfers to meet domestic demand.

Table 5: Positive Indigenization List (Compiled from Ministry of Defence)

Positive Indigenization List	
1st List	235
2nd List	108
3rd List	101
4th List	101
5th List	346

Source: Ministry of Defence, India

- **Defence Production and Export Promotion Policy (DPEPP) FY2020:**
  Launched in August FY2020 as the central policy framework for India's defence industrial roadmap.
  Strategic Targets:
  - USD 25 billion in total defence production by FY2025.
  - USD 5 billion in annual defence exports.

- **Higher FDI Limits and Investment Incentives:**
  In FY2020, the automatic route FDI cap increased from 49% to 74% to allow foreign OEMs majority control in Indian ventures without prior approval. FDI up to 100% allowed on a case-by-case basis for projects involving critical or niche technologies. Accompanied by:
  - Liberalized licensing norms for dual-use and defence items.
  - Single-window digital platform for industrial clearances and compliance.

- **Budgetary Prioritization of Domestic Procurement:**
  The Ministry of Defence has progressively ringfenced capital procurement for Indian firms:
  - **FY2021–22:** 58% reserved for domestic sourcing.
  - **FY2022–23:** increased to 68%.
  - **FY2023–24:** record 75% (INR 1 lakh crore out of INR 1.63 lakh crore).

5.7 Key Trends in the Indian Defense Industry

Several dominant trends are now shaping the trajectory of India's defence industry, reflecting the impact of the indigenization drive, policy reforms, and the changing strategic context. These trends highlight how India's defence sector is positioning itself for the future, in terms of military capability, industrial opportunities, and geopolitical alignment:

5.7.1 Stronger Self-Reliance and Indigenous Innovation

- **Shift to Domestic Design and Production:** Import content in India's defence systems has dropped significantly—from 65–70% two decades ago to ~35% today. About 65% of defence requirements are now met domestically.
- **Strategic Autonomy and Resilience:** This transition enhances India's ability to manage crises independently, minimizing disruption from sanctions or foreign supply shocks.
- **Innovation Ecosystem:** iDEX, increased R&D allocations, and DRDO-private sector partnerships have enabled breakthroughs in hypersonics, artificial intelligence, unmanned combat aerial vehicle, and next-gen platforms like Advanced Medium Combat Aircraft (AMCA).

5.7.2 Rising Defense Exports and "Make in India for the World"

- **Export Trajectory:** Defence exports reached INR 21,000 crore in FY2024, with goals to scale to INR 35,000–50,000 crore (~USD 5–6 billion) by FY2030.
- **Product Mix:** Exports span missiles (BrahMos, Akash), patrol boats, aircraft spares, radars, and body armour, showcasing multi-domain capability.
- **Diplomatic Leverage:** Platforms like Tejas, BrahMos, and Akash are marketed to nations in Southeast Asia, Africa, and the Middle East, reinforcing India's role as a strategic partner.

5.7.3 Expanding Private Sector and MSME Participation

- **Diversified Participation:** Large players (Tata, L&T, Mahindra) and startups are now involved across domains—naval platforms, artillery, missiles, electronics, and drones.
- **Growing Share:** Private firms now contribute ~20% of total defence production.
- **MSME Backbone:** 16,000+ MSMEs serve as critical suppliers, supporting component and sub-system delivery for larger platforms.

5.7.4 Public Sector Modernization and Efficiency Gains

- **OFB Reforms:** In FY2021, OFB was split into 7 DPSUs to improve accountability and specialization.
- **Production and Export Push:** DPSUs like HAL and BEL are streamlining operations and securing export orders (e.g., Tejas, helicopters).
- **Public-Private Synergy:** DRDO increasingly engages private players for production, as seen in joint efforts like the ATAGS howitzer with Tata and Bharat Forge.

5.7.5 Steady Increase in Defense Spending and Modernization

- **Budgetary Growth:** India's defence outlay rose from INR 2.53 lakh crore (FY2013–14) to INR 6.81 lakh crore (FY2025–26), now the world's 3rd largest military spender.
- **Capital Investment:** More funds are now earmarked for modernization (e.g. FICV, 45,000-tonne warships, UCAVs), with projects increasingly routed through Indian firms.
- **Strategic Alignment:** Military capability roadmaps are being aligned with industrial capacity plans—ensuring predictable demand pipelines.
- **Industry Opportunity:** With projected defence spending to hit ~USD 100 billion annually by FY2030, Indian industry is positioned for a decade of exponential opportunity.

5.8 India's Defense Modernization Programs and Procurement Opportunities

5.8.1 Programs under the Indian Navy

Table 6: Key Programs under the Indian Navy

Program Name	Budget	Timeline Expected (FY)	Electro-Optical/Infrared Relevance
Next Generation Destroyers (Project 18) - 8–10 nos.	USD 10+ billion	Construction start ~FY2027, deliveries FY2032+	Panoramic IRST, multiple EO fire-control systems (EOFCs), and EO integration for missile cells (144 VLS).
Next Generation Frigates (Project 17B) – 7-8 nos.	~USD 8.1 billion (₹70,000 cr)	Contract FY2026, deliveries FY2030+	Indigenous EOFCs, IRST, and missile seeker/launcher EO integration.
Mine Counter Measures Vessels (MCMV) – 12 nos.	~USD 5.1 billion (₹44,000 cr)	Selection FY2026, deliveries FY2030–FY2037	Electro-Optical/Infrared payloads for both motherships and autonomous mine-hunting systems.
Extra Large Unmanned Underwater Vehicles (XLUUV) – 12 nos.	~USD 290 million (₹2,500 cr)	Prototype FY2026, 12 units by FY2030+	Retractable mast with compact Electro-Optical/Infrared seeker package.
Autonomous Surface Vessels (USV/ASV) – 12+ units	Not disclosed	FY2027+	360° panoramic Electro-Optical/Infrared for autonomous navigation and situational awareness.
Multi-Mission Support Ships (MMSS) – 2 nos.	Not disclosed	FY2027–FY2029	Long-range Electro-Optical/Infrared systems integrated with EOFCs for targeting and surveillance.

Source: Ministry of Defence, India

5.8.2 Programs under the Indian Army

Table 7: Key Programs under the Indian Army

Program Name	Budget	Timeline Expected	Electro-Optical/Infrared Relevance
Future Ready Combat Vehicle (FRCV) – 1,770 nos.	~USD 17.4 billion (₹1.5 lakh cr)	Prototypes by FY2027; induction FY2030	360° Commander's Sight and Gunner's Thermal Sight with Electro-Optical/Infrared; critical for anti-tank guided missiles and integration with command launcher/fire-control systems.
Zorawar Light Tank – 300-350 nos.	Not disclosed	User trials FY2025; induction FY2026–27	Compact stabilized Electro-Optical/Infrared sighting for GLATGM and RWS integration; panoramic sights to support all-weather surveillance.
Arjun Mk-1A & Mk-II Upgrade – 118 (Mk-1A); Mk-II TBD	Not disclosed	Mk-1A deliveries FY2024–26; Mk-II by FY2026–27	Commander's Panoramic Sight and advanced COAPS Electro-Optical/Infrared systems integrated with guidance and missile fire-control units.
T-72 Combat Improved Ajeya (CI-Ajeya) – 1,000 nos.	Not disclosed	Completion by FY2026	Fire-control system overhaul; Electro-Optical/Infrared upgrades central to modernization.
K9 Vajra-T Self-Propelled Howitzer – 200+ nos.	~USD 8.8 billion (₹7,628.7 cr)	Deliveries FY2025–28	Electro-Optical/Infrared-driven PWGS domain: terminal seekers for precision-guided artillery munitions (imaging IR/laser).
Advanced Towed Artillery Gun System (ATAGS) – 307 nos.	~USD 927 million (₹8,000 cr)	Manufacturing from FY2025	Advanced Electro-Optical/Infrared terminal seekers and targeting kits for precision fires.

Source: Ministry of Defence, India

5.8.3 Programs under the Indian Air Force

Table 8: Key Programs under the Indian Air Force

Program Name	Budget	Timeline Expected (FY)	Electro-Optical/Infrared Relevance
Advanced Medium Combat Aircraft (AMCA) – 120-125 nos (Air Force & Navy)	~USD 1.7 billion (₹15,000 cr, prototype phase)	Prototype rollout FY2028–29; first flight FY2029; induction FY2034; series production FY2035	Advanced Electro-Optical/Infrared suite: forward-looking EOTS, IRST, and DAS with embedded IR sensors. Linked to seekers for precision-guided munitions integrated into the weapons bay.
LCA Tejas Mark 1A - 83 ordered + 97 planned	~USD 5.6 billion (₹48,000 cr + ₹67,000 cr)	Deliveries FY2025–FY2029; full fleet by FY2031–32	Lightweight Electro-Optical/Infrared pods and PWGS integration with laser-guided bombs and IR-guided missiles for precision strike.
LCA Tejas Mark 2 – 120 nos. (up to 210 expected)	~USD 1.2 billion (₹10,000 cr)	First flight FY2025–26; operational FY2028; mass production FY2029–30	Advanced IRST, Electro-Optical/Infrared pods, and associated seekers to support expanded strike and air-superiority roles.
Multi-Role Fighter Aircraft (MRFA) – 114 nos.	~USD 13.9-17.4 billion (₹1.20–1.50 lakh cr)	RFP FY2025–26; induction post-FY2028	Electro-Optical/Infrared targeting pods, missile seekers, and PWGS systems under co-production and ToT frameworks.
Super Sukhoi Upgrade (Su-30 MKI) - 84 nos. (up to 259 expected)	~USD 6.9–7.3 billion (₹60,000–63,000 cr)	D&D FY2025–30; upgrades through FY2040	Electro-Optical/Infrared modernization with new targeting pods and IRST systems, enabling integration of next-gen missiles with PWGS seekers.
Jaguar DARIN-III Upgrade – 120 nos.	~USD 3 billion (engines; INR not specified)	Service extension to FY2035+	Advanced Electro-Optical/Infrared reconnaissance pods and PWGS kits for bombs/missiles; sustainment of deep-strike role.

Source: Ministry of Defence, India

5.8.4 Development Programs under Defense Public Sector Undertaking (DPSU)

Table 9: Key Development Programs under DPSUs.

Program Name	Budget	Timeline Expected (FY)	Electro-Optical/Infrared Relevance
Hypersonic Missile Programs (Project Vishnu, BrahMos-II – 12 systems)	Not disclosed	Development; first test FY2024; more tests FY2025–27	Advanced terminal seeker capable of operating through plasma sheath at hypersonic speeds. Likely state-of-the-art IIR seeker or specialized RF/millimeter-wave radar with hardened optics.
BrahMos II (Hypersonic Cruise Missile)	Not disclosed; high cost, R&D intensive	Advanced R&D; ground test FY2025; flight test FY2026–27	Robust IIR/RF terminal seeker and PWGS able to survive hypersonic conditions and guide with extreme precision beyond Mach 5.
Vehicle-Mounted Laser Directed Energy Weapon Mk-II(A)	Not specifically disclosed for this program	Field trials completed April FY2025; induction expected to begin late FY2025–FY2026	Directed Energy System (DES–HPL): Electro-Optical/Infrared stabilization for laser beam control and target tracking.
DURGA-II (Directionally Unrestricted Ray-Gun Array, prototype)	Approx. $100 million allocated for DURGA-II development	Prototype test in FY2025; operational induction likely post-FY2026	Advanced Electro-Optical/Infrared target acquisition modules for aiming and beam stabilization.
High Power Microwave (HPM) DEW ("WaveStrike" & DRDO HPM)	Not specifically disclosed for this program	Induction expected by late FY2026; ongoing trials and prototype deployments	Electro-Optical/Infrared subsystems to track, classify, and lock onto drones/UAS prior to disruption via microwave pulses.
Project Surya (modular scalable DEW)	Not disclosed	300 kW demo by FY2027; megawatt-class future systems	Electro-Optical/Infrared modules essential for beam alignment, precision tracking, and adaptive optics in scalable power configurations.

Source: Ministry of Defence India, Frost & Sullivan Analysis

6 Strategic Defense Electronics Industry

Defense electronics are the sensor, computing, communications, and control subsystems that let military platforms sense, decide, and act. They span sensing (Electro-Optical/Infrared, radar, ESM/EW, acoustic), navigation and timing (INS, GNSS, altimetry), onboard processing and AI (mission computers, DSP/FPGA/GPU, data-fusion), secure communications and networking (RF datalinks, SATCOM, FSO), human–machine interfaces (displays, sights), power/thermal management, and weapon electronics (seekers, fuzes, guidance and fire-control). These rugged, low-SWaP, cyber-resilient building blocks cut across soldiers, vehicles, ships, aircraft, missiles, and unmanned systems, and integrate with C4Intelligence, Surveillance, and Reconnaissance (ISR) for interoperable, network-centric operations.

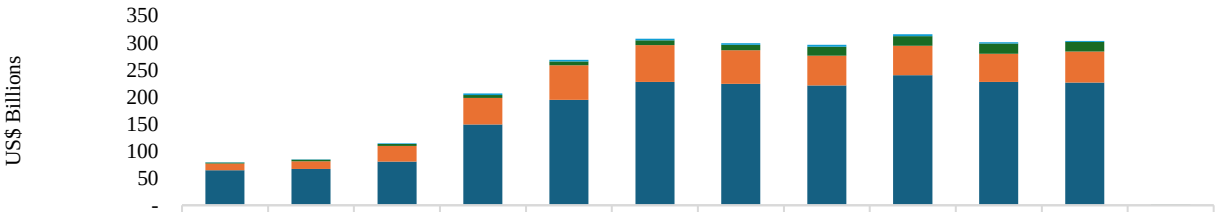
6.1 Market Sizing for Defense Electronics

The global defense electronics market expanded from USD 64.8 billion in CY2020 to a projected USD 226.8 billion by CY2030, reflecting a CAGR of 13.3%. Growth is driven by digitization, modernization of legacy platforms, and rising demand for electronic warfare and surveillance.

Key drivers across all markets include:

- **Electronic Warfare (EW), C4Intelligence, Surveillance, and Reconnaissance (ISR), and Sensor Fusion:** Militaries are prioritizing spectrum dominance, integrating EW with C4Intelligence, Surveillance, and Reconnaissance (ISR) to detect and disrupt adversaries, and deploying multi-domain sensor fusion (Electro-Optical/Infrared, RF, acoustic) for real-time intelligence. Interoperability across architecture is becoming a strategic necessity.
- **High Budgets:** Sustained allocations in the U.S., China, India, and Europe fund modernization, Intelligence, Surveillance, and Reconnaissance (ISR) expansion, and procurement of advanced systems, securing long-term demand.
- **Evolving Threats:** Cyberattacks, grey-zone tactics, and hybrid warfare are driving investment in layered, multi-domain defense—including network resilience, space-based Intelligence, Surveillance, and Reconnaissance (ISR), and rapid-response capabilities.
- **Technological Advances:** AI and machine learning accelerate detection and targeting; edge computing enables low-latency processing at the source; quantum-secure networks strengthen command continuity against cyber and EW threats.

Figure 26: Defense Electronics Market Forecast, Global & Growth Markets, CY2020-CY2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Growth Markets	0.70	0.96	1.39	2.73	3.04	3.15	3.33	3.47	3.53	2.44	1.71	9.3%
India	2.20	2.93	3.57	5.40	7.53	8.66	9.85	16.89	18.14	18.92	17.83	23.3%
Europe	11.90	13.81	28.80	49.32	63.36	68.06	62.28	54.92	54.09	51.88	57.29	17.0%
Global	64.98	67.26	80.95	149.28	195.11	227.94	224.20	221.30	240.50	227.98	226.82	13.3%

"Growth Markets" refers to emerging defense electronics markets including the Philippines, Indonesia, Nigeria, and Morocco.
Source: Frost & Sullivan

6.1.1 Europe

- Market projected to grow from USD 11.9 billion (CY2020) to USD 57.3 billion (CY2030), CAGR 17.0%.
- Growth driven by NATO modernization pressures, with allies pledging in July 2025 to raise defense spending to 5% of GDP by CY2035 (up from the 2% baseline).
- The Russia–Ukraine war has accelerated investments in C4Intelligence, Surveillance, and Reconnaissance (ISR), integrated air defense, and EW systems.
- EU-led programs (PESCO, EDF) are fueling collaborative procurement of digital battlefield systems and secure communications.
- Clear pivot toward sovereign electronics and cyber-defense capabilities, reducing reliance on U.S. and Israeli suppliers.

6.1.2 India

- Market forecast to expand from USD 2.2 billion (CY2020) to USD 17.83 billion (CY2030), CAGR 23.3% — the fastest globally.
- Driven by indigenization initiatives (Make in India, iDEX), fostering a wave of local OEMs and startups.
- Procurement emphasizes AI-enabled surveillance, secure comms, and sensor fusion across services.
- Modernization roadmap prioritizes radars, EW suites, and integrated C2 infrastructure, particularly for northern borders and the IOR.
- Rising exports of Indian-developed systems to Southeast Asia and Africa are expected to enhance scale and competitiveness.

6.1.3 Growth Markets (Philippines, Indonesia, Nigeria, Morocco)

- Collectively growing from USD 699 million (CY2020) to USD 1.7 billion (CY2030), CAGR 9.3%, peaking in CY2028.
- **Philippines & Indonesia:** Rapid maritime-domain and Intelligence, Surveillance, and Reconnaissance (ISR) investments, supported by U.S. FMF and Japanese/Australian grants.
  - Philippines: Contracted Shore-Based Air Surveillance Radars from Japan; MoUs with U.S. for C4Intelligence, Surveillance, and Reconnaissance (ISR) upgrades.
  - Indonesia: Procuring long-range radar networks, UAV-based Intelligence, Surveillance, and Reconnaissance (ISR), and naval combat system upgrades.

6.2 Contribution of Defense Electronics in the Overall Defense Equipment Industry

Defense electronics has steadily increased its share of the total cost composition of defense platforms over the past decade, a trend that is set to accelerate through CY2030. Across most modern military systems —surface combatants, combat aircraft, unmanned systems and ground vehicles — electronics now account for 30% to 60% of total platform costs, as militaries globally pivot toward connected, digital, and autonomous warfare.

Table 10: Electronics Share in Combat, Support, and Strategic Platforms

Platform Type	Electronics Share (% of Total System Cost)	Key Electronic Systems, & Subsystems
Combat Aircraft	40-50%	Avionics suites, EW (Electronic Warfare) systems, radar, secure datalinks, sensor fusion for Intelligence, Surveillance, and Reconnaissance (ISR) & targeting
Combat Vehicles (BMTs, APCs, Recon Vehicles)	35-60%	Digitized fire-control systems, Battlefield Management Systems (BMS), active protection systems, Electro-Optical/Infrared surveillance payloads
Surface Combatants & Submarines	30-50%	Navigation systems, sonar, EW, secure communications, integrated combat management systems, radar/weapon control suites, EMP hardening
Support Vessels (Landing Ships, Logistics Platforms)	30-36%	Radar, communication relays, missile defense systems, C2 (Command & Control) infrastructure
Missile Systems & UAS Platforms	Up to 60%	Advanced seeker heads, navigation systems, secure datalinks, onboard computing for guidance & control
Radars, EW Pods, Communication Notes	~100%	Fully electronic systems including radar transmit/receive modules, EW jammers, secure communication nodes, signal processing units

Source: Frost & Sullivan

This rising electronic content is fundamentally reshaping procurement strategies. Rather than focusing solely on hulls, airframes, or mobility systems, modern militaries are prioritizing electronic performance, interoperability, and survivability in contested environments. As a result:

- Defense electronics is growing faster than the overall defense equipment market, with its share of total defense spending expected to climb from ~25% in CY2020 to over 35% by CY2030.
- This shift is even more pronounced in programs involving Intelligence, Surveillance, and Reconnaissance (ISR), integrated air defense, multi-domain command and control, and autonomous systems, where electronics dominate both cost and capability envelopes.
- A growing global trend in modern battlefield digitisation is the adoption of ATAK as a de-facto standard for connected soldier systems and real-time information sharing. ATAK is a global standard for connected systems on the battlefield and information sharing. It provides better situational awareness by assimilating information from sights, handheld imagers and drone imagery.

6.3 Value Chain of Defense Electronics

The defense electronics industry underpins modern military capability by enabling sensing, decision support, communication, and engagement. These functions span Observation, Understanding, Communication, and Offensive systems, which together form the backbone of network-centric warfare. Electronics now account for a growing share of equipment value as militaries modernize aircraft, missiles, radars, and communication suites.

6.3.1 Observation

- Provides situational awareness across land, air, sea, and space through Intelligence, Surveillance, and Reconnaissance (ISR) platforms: Electro-Optical/Infrared sensors, radars, sonar, Unmanned Aerial Vehicles (UAVs), Airborne Warning and Control System (AWACS), and satellites.
- Space-based sensors and persistent drones are expanding coverage; example: Joint STARS radar aircraft tracking mobile ground units.
- Conflicts in Ukraine and Gaza underscore rising demand for persistent Intelligence, Surveillance, and Reconnaissance (ISR) and drone-based surveillance as early-warning and targeting tools.

Figure 27: A Royal Australian Air Force E-7A Wedgetail. It provides airborne surveillance and early warning systems.

Source: US Air Force

Table 11: Observation Value Chain, Global

Company	Country	Sector	Portfolio/Edge	Recent Launch/ Partnership	Revenue (CY2024)
Lockheed Martin	USA	Private	Tier-1 multi-domain Intelligence, Surveillance, and Reconnaissance (ISR): AEW&C, space EO/SAR payloads, tactical Electro-Optical/Infrared turrets, distributed sensing	New payload and software refreshes across Intelligence, Surveillance, and Reconnaissance (ISR) mission systems; continued integrations with manned–unmanned teams	USD 71.0 Billion
Northrop Grumman	USA	Private	Global leader in AEW&C/GMTI radars, HALE Intelligence, Surveillance, and Reconnaissance (ISR) (e.g., Triton class), multi-sensor fusion	Next-gen AESA radar & GMTI enhancements; autonomous Intelligence, Surveillance, and Reconnaissance (ISR) constructs	USD 41.0 Billion
Thales	France	Government-linked	Strong Electro-Optical/Infrared turrets, optronics, maritime Intelligence, Surveillance, and Reconnaissance (ISR), border-surveillance systems	New-gen optronic sights/EO turrets and coastal Intelligence, Surveillance, and Reconnaissance (ISR) system upgrades	USD 24.1 Billion

Israel Aerospace Industries	Israel	Private	Full-stack Intelligence, Surveillance, and Reconnaissance (ISR): MALE UAVs, maritime patrol suites, Electro-Optical/Infrared turrets	New payload/ mission-suite updates; regional co-production MoUs	USD 6.1 Billion
Rafael	Israel	Government-linked	Air/ground radars, optronics, integrated border/coastal Intelligence, Surveillance, and Reconnaissance (ISR)	New TRS/AESA variants; optronics refresh for land/naval Intelligence, Surveillance, and Reconnaissance (ISR)	USD 4.9 Billion
Leonardo	Italy	Government-linked	Electro-Optical/Infrared turrets, AESA radars, maritime patrol Intelligence, Surveillance, and Reconnaissance (ISR) suites	Electro-Optical/Infrared turret upgrades; MPA mission system wins	USD 20.7 Billion
Airbus Defence & Space	EU	Government-linked	Space EO/SAR constellations, manned Intelligence, Surveillance, and Reconnaissance (ISR) (C-295 MPA), HAPS	HAPS/space imaging updates; Intelligence, Surveillance, and Reconnaissance (ISR) mission kit upgrades	USD 14.0 Billion

Company	**Country**	**Sector**	**Portfolio/Edge**	**Recent Launch/ Partnership**	**Revenue (FY2025)**
Bharat Electronics Ltd.)	India	Public (PSU)	Prime Intelligence, Surveillance, and Reconnaissance (ISR) electronics: radars, Electro-Optical/Infrared sights, coastal/border Intelligence, Surveillance, and Reconnaissance (ISR)	New coastal Intelligence, Surveillance, and Reconnaissance (ISR) nodes & Electro-Optical/Infrared integrations with services	INR 237,687 Million
Data Patterns	India	Private	Niche Intelligence, Surveillance, and Reconnaissance (ISR)/avionics subsystems, Electro-Optical/Infrared electronics, ground stations	Payload electronics & avionics wins	INR 7,083 Million
ideaForge	India	Private	Market-leading small-UAV Intelligence, Surveillance, and Reconnaissance (ISR) platforms	New long-endurance mini-UAV & payloads deliveries	INR 1,612 Million
Alpha Design Technologies	India	Private	Electro-Optical/Infrared sights, Intelligence, Surveillance, and Reconnaissance (ISR) integration, offsets/JVs	New integrations with DPSUs/foreign OEMs	INR 4,392 Million (approx.)
Tonbo Imaging	India	Private	Low-SWaP Electro-Optical/Infrared Intelligence, Surveillance, and Reconnaissance (ISR) payloads; edge ATR; ATAK-native	Spartan refresh; GeoC/Gazehound; DRDO/DPSU Intelligence, Surveillance, and Reconnaissance (ISR) integrations	INR 4,690 Million

Source: Frost & Sullivan Analysis

6.3.2 Understanding

- Converts multi-sensor data into actionable intelligence via target acquisition radars, fire-control systems, AI/ML analytics, and fusion algorithms.
- AI-enabled systems distinguish real threats from clutter or decoys in real time (e.g., UAV video feeds, radar returns).
- Automation at the tactical edge—onboard UAVs, armored vehicles, and naval platforms—reduces latency and accelerates the OODA loop (observe, orient, decide, act).

Figure 28: A Finnish Ground Master 400. It is a mobile long range radar system which can detect tactical aircrafts, UAVs and cruise missiles.

Table 12: Understanding Value Chain, Global

Company	Country	Sector	Portfolio/Edge	Recent Launch/ Partnership	Revenue (CY2024)
Raytheon Technologies	USA	Private	Tier-1 fire-control, IADS, interceptors; multi-sensor fusion and battle-management software	Upgrades across air & missile defense C2/fusion suites; new radar/FCR refreshes	USD 80.7 Billion
BAE Systems	UK	Private	Electronic systems, targeting pods, mission computers, EW/C2 integration	New FCR/mission-computer inserts; AI-assisted targeting & EW integration	USD 33.0 Billion
Elbit Systems	Israel	Private	Battle-management systems (BMS), fire-control, C4Intelligence, Surveillance, and Reconnaissance (ISR) apps; AI at the tactical edge	New BMS exports and turret/fire-control packages; ATR/edge-AI updates	USD 6.8 Billion
Palantir Technologies	USA	Private	Data fusion/AI decision platforms; cross-domain intel integration	Defense AI/ML operations expansions with allied MoDs	USD 2.9 Billion
Hensoldt	Germany	Private	Surveillance radars + fusion/C2 layers for GBAD & coastal Intelligence, Surveillance, and Reconnaissance (ISR)	New AESA/radar family refresh and fusion middleware	USD 2.6 Billion
Thales	France	Governme nt-linked	C4I, Surveillance, and Reconnaissance (ISR) suites, optronics + AI analytics; air/land/naval combat systems	New C2/AI modules and BMS exports	USD 24.1 Billion

Leonardo	Italy	Governme nt-linked	AESA radars, mission computers, integrated C2 for air & naval	Mission-system upgrades and MPA/Intelligence, Surveillance, and Reconnaissance (ISR) C2 deliveries	USD 20.7 Billion
Israel Aerospace Industries	Israel	Private	Mission systems for UAV/MPA; AI-enabled exploitation & C2	New UAV mission-suite & maritime C2 wins	USD 6.1 Billion

Company	Country	Sector	Portfolio/Edge	Recent Launch/ Partnership	Revenue (FY2025)
Bharat Electronics Ltd.	India	Public (PSU)	Prime contractor for C4I, BMS, air-defense fire-control, coastal/border C2	New command posts/BMS nodes & FCR integrations with Services	INR 237,687 Million
Tata Advanced Systems	India	Private	Mission systems & avionics integration; Intelligence, Surveillance, and Reconnaissance (ISR)/C2 packages with OEM partners	Avionics/mission-system integrations; joint programs with global primes	INR 51,231 Million
Tonbo Imaging	India	Private	Electro-Optical/Infrared edge-AI (ATR & fusion), passive targeting processors, uncooled dual-mode seeker.	DRDO IIR-seeker (FY2024); ATAK-integrated sights/payloads.	INR 4,690 Million

Source: Frost & Sullivan Analysis

6.3.3 Communication

- Acts as the "nervous system" of modern forces, linking sensors, C2 nodes, and shooters.
- Includes tactical radios, SATCOM, software-defined radios, and 5G-derived mesh networks.
- Free-Space Optical (FSO) links and emerging quantum-secure networks offer high bandwidth and resilience against EW threats.
- Examples: U.S. JADC2 for redundant multi-path routing; India's Defense Communication Network for secure, assured C3.

Figure 29: Joint Operations Center aboard the command ship USS Mount Whitney

Source: US Navy

Table 13: Communication Value Chain, Global

Company	Country	Sector	Portfolio/Edge	Recent Launch/ Partnership	Revenue (CY2024)
L3 Harris Technologies	USA	Private	Global leader in SDR tactical radios, MANET, data links, airborne & maritime comms; crypto & Type-1 heritage	New SDR/MANET waveform refreshes and multi-service interoperability awards	USD 21.3 Billion
Thales Group	France	Government-linked	Tier-1 for soldier radios, naval comm suites, secure SATCOM/C2; end-to-end cryptography	Next-gen soldier radio & naval comms upgrades with allied MoDs	USD 24.1 Billion
General Dynamics Mission Systems	USA	Private	Battlefield networking, tactical gateways, SATCOM ground seg., Blue-Force/MDT C2	Gateway/transport modernization awards; SATCOM terminal refresh	USD 47.7 Billion
Airbus Defense & Space	EU	Government-linked	MILSATCOM prime, secure gov networks, airborne comms; pan-EU programs	MILSAT/secure network upgrades & national backbone extensions	USD 14.0 Billion
QinetiQ	UK	Private	Niche RF, EW-resilient comms, telemetry, assured PNT; test & eval for comm resilience	Protected comms/RF resilience pilots with UK/EU customers	USD 2.6 Billion

Company	Country	Sector	Portfolio/Edge	Recent Launch/ Partnership	Revenue (FY2025)
Bharat Electronics Ltd.	India	Public (PSU)	Prime for tri-service SDR, tactical networks, naval/air comms, crypto; large-scale production	New SDR family rollouts & secure network nodes for Services	INR 237,687 Million
Astra Microwave Products Ltd.	India	Private	RF/microwave subsystems for SATCOM & radars; payload/ground-seg. builds	New RF front-ends & SATCOM subsystem wins with Indian primes	INR 10,512 Million
Centum Electronics	India	Private	Avionics & communication electronics, power/RF modules; space & defense heritage	Fresh LRUs for comm/navigation stacks with DPSUs/OEMs	INR 11,641 Million
Tonbo Imaging	India	Private	Stabilized FSO links; compact optical terminals; ATAK video/track.	Vehicular/mast FSO trials; gimbal-integrated link control	INR 4,690 Million
Saankhya Labs	India	Private	Software-defined radios, SATCOM/terrestrial waveforms, edge modems	New SDR chipsets & modem platforms for defense/dual-use comms	NA

Source: Frost & Sullivan Analysis

6.3.4 Offensive

- Encompasses precision-guidance electronics (GPS/INS, laser, IR, MMW seekers) for munitions, alongside Directed Energy Weapons (DEWs).
- Loitering munitions integrate Intelligence, Surveillance, and Reconnaissance (ISR) and strike in one platform, enabling autonomous engagements.
- HELs: U.S. Navy's LaWS, Israel's Iron Beam, and India's CY2025 DRDO laser trial (30 kW, drones neutralized at 5 km, ~$8k/shot) highlight operational advances.
- HPM systems are proving effective in counter-UAS roles, while future DEW programs aim for 100–300 kW class systems across land, sea, and air platforms.

Figure 30: Directed Energy and Electric Weapon Systems Program Office of the US Navy

Source: US Navy

Table 14: Offensive Value Chain, Global

Company	Country	Sector	Portfolio/Edge	Recent Launch/ Partnership	Revenue (CY2024)
Lockheed Martin (USA)	USA	Private	Tier-1 for PGMs (JASSM class), seekers & guidance, and HEL (ship/land) integration	New precision-strike increments & HEL integration milestones	USD 71.0 Billion
Raytheon Technologies (USA)	USA	Private	Prime in air/air-defense interceptors, seekers, fuzes; HPM/RF effects R&D	Next-gen seeker/warhead upgrades; C-UAS effectors	USD 80.7 Billion
Northrop Grumman (USA)	USA	Private	Guidance, avionics, advanced seekers, and power/thermal for HEL	New seeker electronics & power conditioning awards	USD 41.0 Billion
Rafael (Israel)	Israel	Private	Combat-proven precision munitions and DES-ready sensors/cueing	Precision-strike kits & C-UAS integrations with allies	USD 4.9 Billion
MDBA (Europe)	Europe	Private	European prime for cruise/anti-ship/air-defense missiles; multi-mode seekers	European cooperative upgrades & export variants	USD 5.7 Billion

Company	Country	Sector	Portfolio/Edge	Recent Launch/ Partnership	Revenue (FY2025)
Bharat Dynamics Ltd.	India	Public (PSU)	National prime for guided missiles; builds seekers/guidance with Indian IP	New production lots & seeker/guidance localization	INR 33,000 Million
Paras Defense & Space Technologies (India)	India	Private	Electro-optics & laser subsystems; development contracts in DE/EO	New EO/laser modules & defense development orders	INR 3,727 Million
Bharat Forge (India)	India	Private	Artillery & smart munitions electronics; fire-control & precision kits	Tie-ups for precision artillery upgrades	INR 153,366 Million

Tonbo Imaging	India	Private	Uncooled dual-mode Electro-Optical/Infrared seekers; AI fire-control/guidance; Electro-Optical/Infrared cueing for HPM/loiterers.	DRDO IIR-seeker (FY2024); loiterer seeker/ATR updates.	INR 4,690 Million

Source: Frost & Sullivan Analysis

6.4 Global Program Opportunities in Defense Electronics

Table 15: Defense Electronics Program Opportunities, Global

Country	Program Name	Budget	Timeline Expected	Contract Links
USA	M-SHORAD Increment 1-4	Undisclosed (700+ units)	Present – CY2035	M-SHORAD Increment 1-4 Procurement
India	Future Ready Combat Vehicle (FRCV)	USD 17.4 Billion (1,200+ units)	FY2030	FCRV Procurement
India	Future Infantry Combat Vehicle (FICV)	$8.80 billion (1,750 units)	FY2028-FY2030	FICV Procurement
India	AMCA	$1.80 billion (125+ units)	FY2034 (First Flight – FY2028)	AMCA Procurement
India	ASW SWC Corvettes	Undisclosed (16 units)	FY2028	Indian Navy ASW-SWC Procurement

Source: Frost & Sullivan Analysis

7 Electro-Optical/Infrared Industry

7.1 Defining Electro-Optical/Infrared Systems and Intelligence, Surveillance, and Reconnaissance (ISR) Applications

7.1.1 Definition and Components

Electro-Optical/Infrared (Electro-Optical/Infrared) systems are advanced sensor suites that combine optical cameras and infrared imagers to detect, track, and identify targets across multiple wavelengths. They integrate:

- Electro-Optical (EO) sensors – capture visible-light imagery with high spatial resolution.
- Infrared (IR) sensors – detect thermal emissions for night vision or visibility through like smoke, fog, or haze.

Figure 31: Sniper equipped with Thermal Sights & Night Vision

Figure 32: A T-90 equipped with "Shtora-1" Electro-Optical/Infrared system

7.1.2 Key Features

- Long-range imaging optics for stand-off surveillance.
- Gyro-stabilization to ensure steady, clear images from moving platforms.
- Multi-spectral coverage enabling detection and identification in varied operational environments.
- Passive operation that detects reflected light or emitted heat without revealing the observer's position.

7.1.3 Role in the Intelligence, Surveillance, and Reconnaissance (ISR) Decision Cycle

Electro-Optical/Infrared imagery (e.g., high-resolution daylight photos or thermal infrared video) feeds directly into the Intelligence, Surveillance, and Reconnaissance (ISR) loop, where it can be fused with other intelligence streams for threat identification and command decision-making.

7.1.4 Civil and Dual-Use Applications

Beyond defense, Electro-Optical/Infrared systems support environmental monitoring, disaster response, and humanitarian operation, such as wildfire tracking, oil spill monitoring, and multi-spectral weather observation from satellites.

7.2 Evolution of Electro-Optical/Infrared Systems: Global and Indian Evolution

7.2.1 Global Evolution

7.2.1.1 CY1940s–1960s: Early Electro-Optical/Infrared Experiments (First Generation)

Electro-optical and infrared sensing began with experimental night-vision scopes and rudimentary heat detectors during World War II, enabling limited visibility in darkness. By the Vietnam War, the first Forward-Looking Infrared (FLIR) units emerged, using rotating optomechanical scanners and cryogenically cooled detectors to produce thermal images for pilots. These early systems were bulky, low-resolution, and deployed only on high-value platforms like reconnaissance aircraft.

7.2.1.2 CY1970s–1980s: Breakthroughs and Standardization (First to Second Generation)

The invention of solid-state focal plane arrays (FPAs) allowed "staring" thermal imagers without moving parts, improving reliability and image quality. The U.S. introduced Common Module FLIR programs, standardizing sensors for multiple platforms. Advances in microelectronics enabled on-board signal processing. Operationally, these systems played pivotal roles in NATO Cold War surveillance and Middle East conflicts, giving commanders the first credible all-weather, night targeting capability.

7.2.1.3 CY1990s–2000s: Multi-Sensor Integration and Battlefield Impact (Second Generation)

This era saw the debut of gyro-stabilized Electro-Optical/Infrared gimbals (e.g., FLIR SAFIRE series), integrating daylight TV, FLIR, and laser rangefinders/designators into one unit. Gulf War I (1991) demonstrated their value, with FLIR-equipped aircraft and tanks detecting camouflaged Iraqi forces at night and through smoke. The CY2000s brought uncooled microbolometer IR cameras (Vanadium Oxide, an amorphous silicon detectors), enabling mass deployment for infantry, vehicles, and UAVs. Meanwhile, cooled mid-wave and long-wave IR sensors improved range for high-end platforms.

7.2.1.4 CY2010–Present: High-Definition, AI Integration, and Miniaturization (Third Generation)

Modern Electro-Optical/Infrared systems now feature high-definition digital sensors, multi-spectral imaging, and networked video streaming. Platforms like L3Harris WESCAM MX-Series and Teledyne FLIR Star SAFIRE incorporate GPS/INS geo-targeting, automated tracking, and optional hyperspectral or laser payloads. AI-enabled processing at the edge shortens the sensor-to-shooter cycle, as seen in Ukraine, where drones with Electro-Optical/Infrared turrets have guided artillery in real time.

7.2.2 Indian Evolution

7.2.2.1 Early Dependence on Imports (pre-FY2014)

For decades, India relied heavily on foreign-made Electro-Optical/Infrared equipment, importing high-performance IR detector arrays (Indium Antimonide/Mercury Cadmium Telluride sensors), precision optics, and stabilized gimbal

assemblies from France, Israel, and the U.S. Examples include LITENING targeting pods for Jaguar and Su-30MKI aircraft from Rafael (Israel) and Catherine thermal sights from Thales (France) for Army tanks.

7.2.2.2 Shift Towards Self-Reliance (FY2014-18)

The Aatmanirbhar Bharat initiative catalyzed indigenous R&D in Electro-Optical/Infrared. DRDO's Instruments Research & Development Establishment (IRDE) and Centre for Airborne Systems (CABS) have developed cooled/uncooled thermal imagers, night sights, and airborne multi-sensor gimbals.

- FY2023 Milestone: CABS unveiled an indigenously developed multi-sensor Electro-Optical/Infrared surveillance system integrating SWIR, day/night cameras, LRF, and laser illuminators, augmented by AI-based auto-tracking.
- Deployment Plans: Systems are slated for Indian Coast Guard maritime patrol aircraft to enhance vessel tracking and oil spill detection.

7.2.2.3 Industry Participation & Production Capacity (FY2019-23)

Bharat Electronics Ltd (BEL) manufactures thousands of Electro-Optical/Infrared products annually—over 15,000 thermal sights and 1,000+ cooled Electro-Optical/Infrared units for Army, Navy, and Air Force in the last five years. Private firms like Tonbo Imaging supply uncooled thermal weapon sights (e.g., Spartan series), IIR missile seekers, and AI-enabled vision systems to both Indian forces and export customers.

7.2.2.4 Recent RFPs & Contracts (FY2023-25)

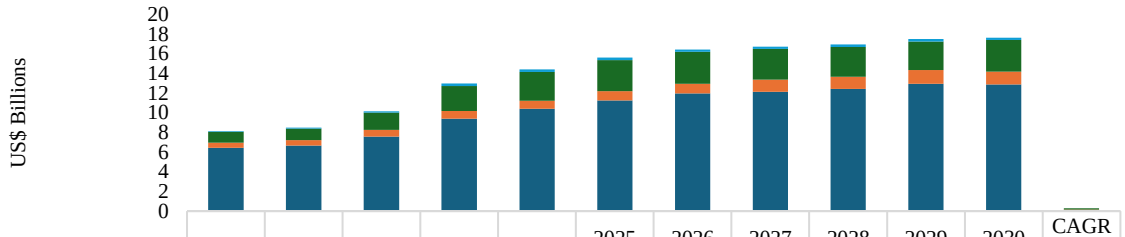
- BEL: Order for 2,000+ commander's thermal imaging sights for T-90 tanks (FY2024).
- Tonbo Imaging: DRDO contract for IIR seekers for tactical missiles (FY2024).
- ideaForge: Awarded Electro-Optical/Infrared payload development for fixed-wing UAV program (FY2023).
- Paras Defence: BEL subcontract for naval IR Search & Track (IRST) systems (FY2024).

7.3 Market Sizing of Electro-Optical/Infrared (CY2020-30)

The global Electro-Optical/Infrared (Electro-Optical/Infrared) systems market is witnessing a strong growth trajectory, expanding from USD 6.4 billion in CY2020 to a projected USD 12.9 billion in CY2030, reflecting a CAGR of 7.2% over the decade.

By comparison, Electro-Optical/Infrared accounted for roughly 9.1% of total defense electronics spending in CY2020, a share expected to moderate slightly to 5.3% by 2030, reflecting faster growth in other electronics categories. Nevertheless, Electro-Optical/Infrared remains strategically indispensable, with fused optical and infrared sensing emerging as a core enabler of next-generation multi-domain Intelligence, Surveillance, and Reconnaissance (ISR) and precision strike architectures.

Figure 33: Electro-Optical/Infrared Market Forecast, Global & Target Markets, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Growth Markets	0.06	0.09	0.11	0.25	0.27	0.26	0.22	0.22	0.24	0.28	0.24	0.16
Europe	1.13	1.19	1.76	2.56	2.92	3.14	3.24	3.14	3.04	2.89	3.22	0.11
India	0.51	0.54	0.69	0.76	0.79	0.95	0.98	1.20	1.23	1.38	1.28	0.10
Global	6.43	6.65	7.56	9.40	10.40	11.24	11.95	12.13	12.40	12.94	12.87	0.07

Source: Frost & Sullivan

7.3.1 Europe

- Europe's Electro-Optical/Infrared market is forecast to grow from $1.13 billion in CY2020 to $3.23 billion by CY2030, with a CAGR of 11.1%.
- European nations are significantly ramping up Intelligence, Surveillance, and Reconnaissance (ISR) capability in response to Russian aggression, resulting in high investment in Electro-Optical/Infrared-enabled UAVs, base defense platforms, and next-gen infantry imaging systems.
- Recent procurements include Thales Sophie Ultima handheld thermal imagers for French forces, Leonardo's Osprey 30 AESA radar with integrated Electro-Optical/Infrared for UK Poseidon MRA1 aircraft, and Hensoldt ARGOS-II HD turrets for German and Baltic maritime patrol aircraft.
- NATO spending mandates and the launch of indigenous European sensor programs are expected to reduce dependency on U.S. and Israeli suppliers.

7.3.2 India

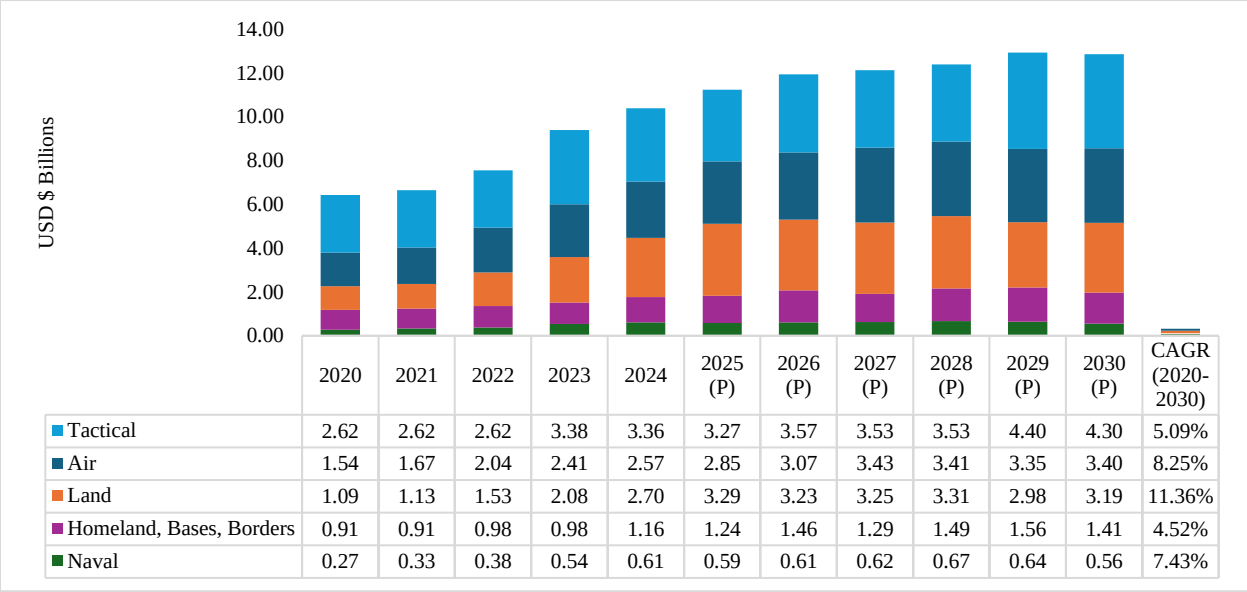
- India's Electro-Optical/Infrared market is expected to surge from $507 million in CY2020 to $1.28 billion by CY2030, representing a CAGR of 9.7%.
- Growth is driven by Atmanirbhar Bharat and Defence Acquisition Procedure (DAP) 2020 mandates that prioritize indigenous sourcing and technology transfer, creating strong demand for locally designed Electro-Optical/Infrared payloads for infantry, border forces, UAVs, and naval platforms.
- India's growth is led by indigenous programs to equip infantry, border forces, and airborne platforms with Electro-Optical/Infrared payloads; key drivers include the deployment of UAV-based surveillance, thermal imagers, and border monitoring radars.
- DRDO, BEL, and private players are engaged in developing Electro-Optical/Infrared turrets, thermal weapon sights, and seeker technologies for missiles and smart munitions.

7.3.3 Growth Markets (Philippines, Indonesia, Nigeria, Morocco)

- The combined Electro-Optical/Infrared market across these growth markets will grow from $57 million in CY2020 to $242 million by CY2030, reflecting a CAGR of 15.6%.
- Southeast Asian countries like the Philippines and Indonesia are prioritizing Electro-Optical/Infrared integration into maritime patrol aircraft, naval corvettes, and coastal radar chains to counter Chinese incursions and piracy threats.
- Nigeria is upgrading its ground Intelligence, Surveillance, and Reconnaissance (ISR) platforms to support counter-insurgency efforts, while Morocco is sourcing Electro-Optical/Infrared systems for UAVs and surveillance towers as part of broader modernization efforts.

7.4 Opportunity Breakdown by Application for Electro-Optical/Infrared Systems (Global)

Figure 34: Electro-Optical/Infrared Market Forecast, By Application, CY2020-CY2030

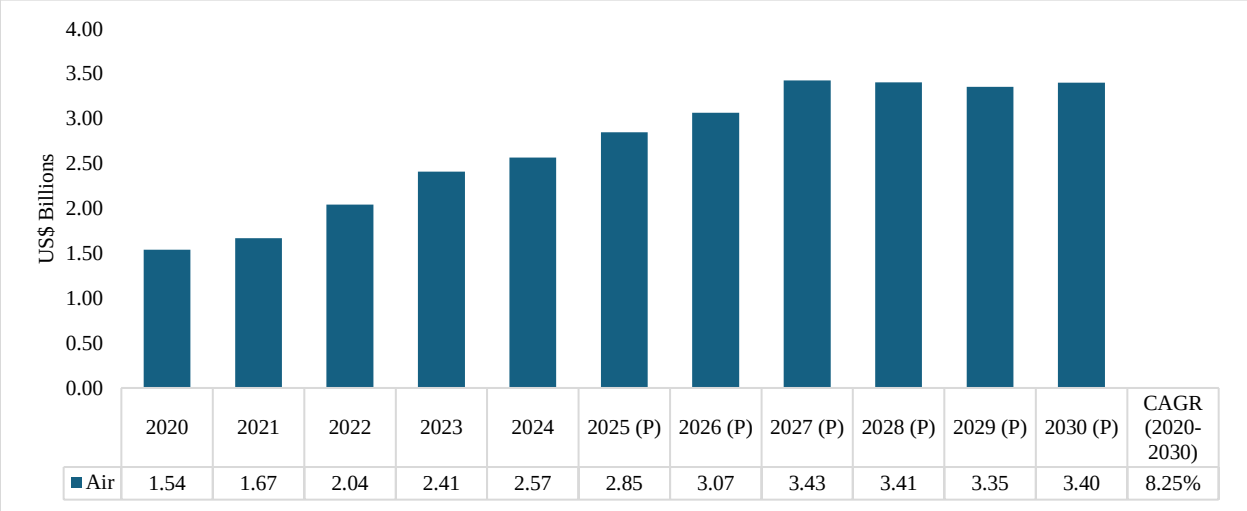


	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Tactical	2.62	2.62	2.62	3.38	3.36	3.27	3.57	3.53	3.53	4.40	4.30	5.09%
Air	1.54	1.67	2.04	2.41	2.57	2.85	3.07	3.43	3.41	3.35	3.40	8.25%
Land	1.09	1.13	1.53	2.08	2.70	3.29	3.23	3.25	3.31	2.98	3.19	11.36%
Homeland, Bases, Borders	0.91	0.91	0.98	0.98	1.16	1.24	1.46	1.29	1.49	1.56	1.41	4.52%
Naval	0.27	0.33	0.38	0.54	0.61	0.59	0.61	0.62	0.67	0.64	0.56	7.43%

Source: Frost & Sullivan

7.4.1 Air

Figure 35: Electro-Optical/Infrared Market Forecast, Air, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Air	1.54	1.67	2.04	2.41	2.57	2.85	3.07	3.43	3.41	3.35	3.40	8.25%

Source: Frost & Sullivan

- The aerial segment, including fixed-wing, rotary, and UAV-based imaging systems, is forecast to grow from $1.54 billion in CY2020 to $3.40 billion in CY2030, achieving a CAGR of 8.3%.
- Modernization of air forces and drone fleets across the globe is accelerating the need for high-resolution, gyro-stabilized, multi-mode Electro-Optical/Infrared payloads.

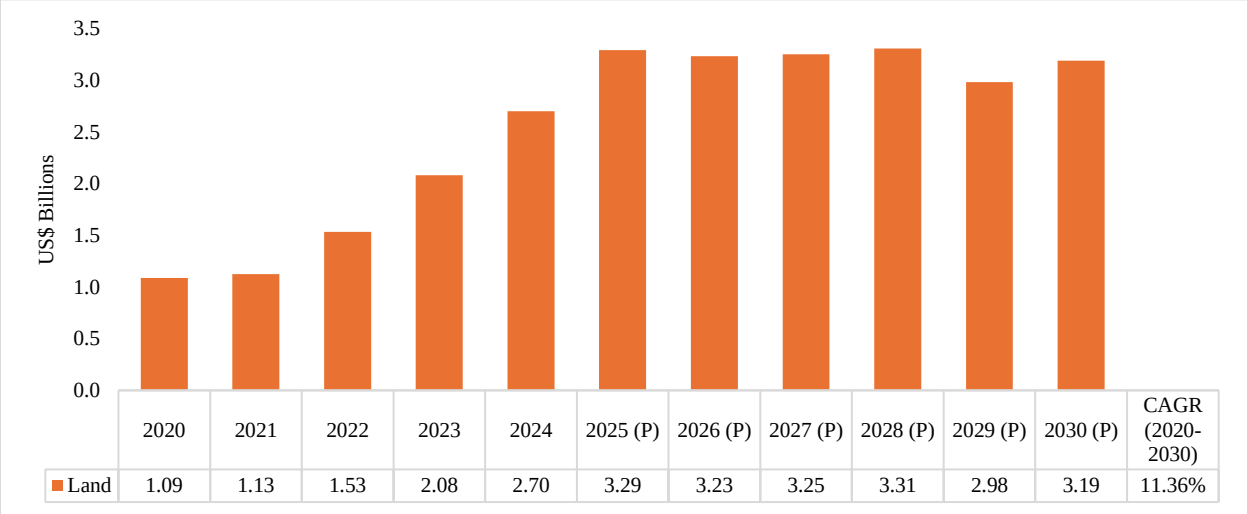
Table 16: Aerial Electro-Optical/Infrared Program Opportunities

Country	Program Name	Budget	Timeline Expected	Contract Links
India	Tejas Mk2	$1.3 billion (230+ units)	FY2029 (First Flight – FY2026)	HAL Tejas Mk2 Procurement

India	AMCA	$1.8 billion (125+ units)	FY2034 (First Flight – FY2028)	AMCA Procurement
Indonesia	Rafale C F3	$8.1 billion (42 units)	CY2026	Indonesia Rafale C F3 Procurement

7.4.2 Land

Figure 36: Electro-Optical/Infrared Market Forecast, Land, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Land	1.09	1.13	1.53	2.08	2.70	3.29	3.23	3.25	3.31	2.98	3.19	11.36%

Source: Frost & Sullivan

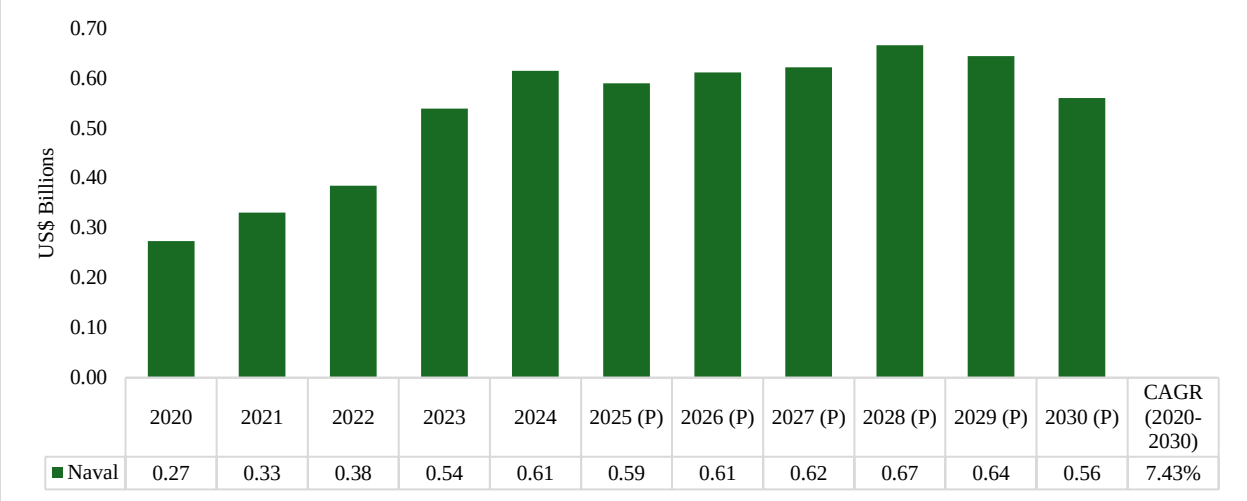
- The land segment, including ground-based platforms, and fixed installations, including main battle tanks (MBTs), infantry fighting vehicles (IFVs), armored personnel carriers (APCs), self-propelled artillery, man-portable weapon sights, and border surveillance towers, will expand from $1.09 billion in CY2020 to $3.19 billion in CY2030, registering a CAGR of 11.36%.
- Demand is concentrated in ground surveillance systems, vehicle-mounted optics, and fixed Electro-Optical/Infrared towers along sensitive borders and high-threat zones.

Table 17: Land Electro-Optical/Infrared Program Opportunities

Country	Program Name	Budget	Timeline Expected	Contract Links
USA	M-SHORAD Increment 1-4	Undisclosed (700+ units)	Present – CY2035	M-SHORAD Increment 1-4 Procurement
India	Future Ready Combat Vehicle (FRCV)	$17.4 Billion (1,200+ units)	FY2030	FCRV Procurement
India	Future Infantry Combat Vehicle (FICV)	$8.8 billion (1,750 units)	FY2028-FY2030	FICV Procurement

7.4.3 Naval

Figure 37: Electro-Optical/Infrared Market Forecast, Naval, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Naval	0.27	0.33	0.38	0.54	0.61	0.59	0.61	0.62	0.67	0.64	0.56	7.43%

Source: Frost & Sullivan

- The naval segment, encompassing surface combatants, submarines, unmanned surface and underwater vehicles (USVs/UUVs), and shipborne surveillance systems, is projected to rise from $273 million in CY2020 to $560 million by CY2030, at a CAGR of 7.43%.
- Growth is underpinned by expanding littoral security missions, blue-water naval ambitions in Asia, and integration of Electro-Optical/Infrared turrets on surface combatants, OPVs, and submarines.

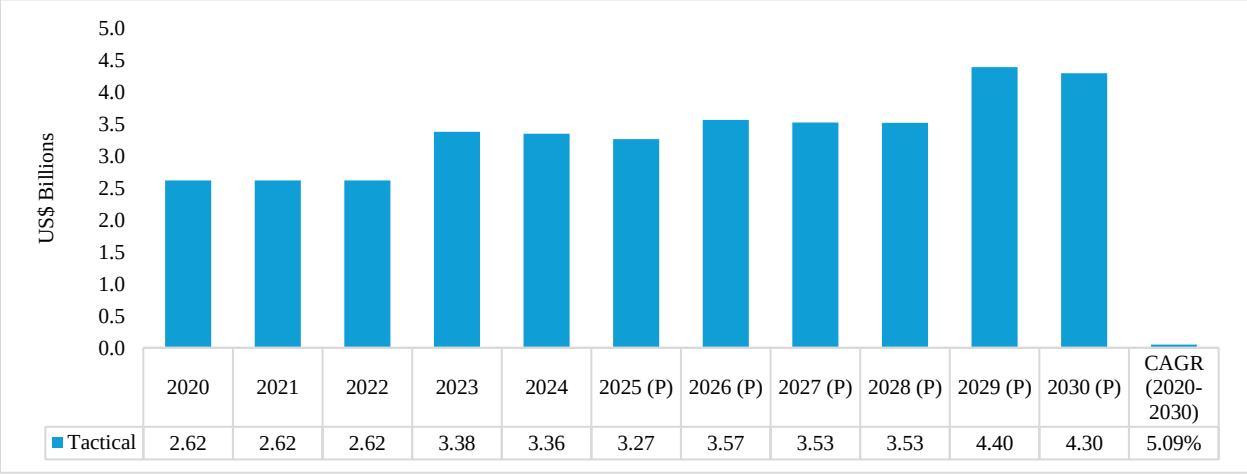
The following table highlights select naval procurement programs driving demand for advanced Electro-Optical/Infrared capabilities at sea.

Table 18: Naval Electro-Optical/Infrared Program Opportunities

Country	Program Name	Budget	Timeline Expected	Contract Links
Indonesia	FREMM Frigates	Undisclosed (6 units)	CY2024-CY2025	Indonesia FREMM Procurement

7.4.4 Tactical

Figure 38: Electro-Optical/Infrared Market Forecast, Tactical, CY2020-2030



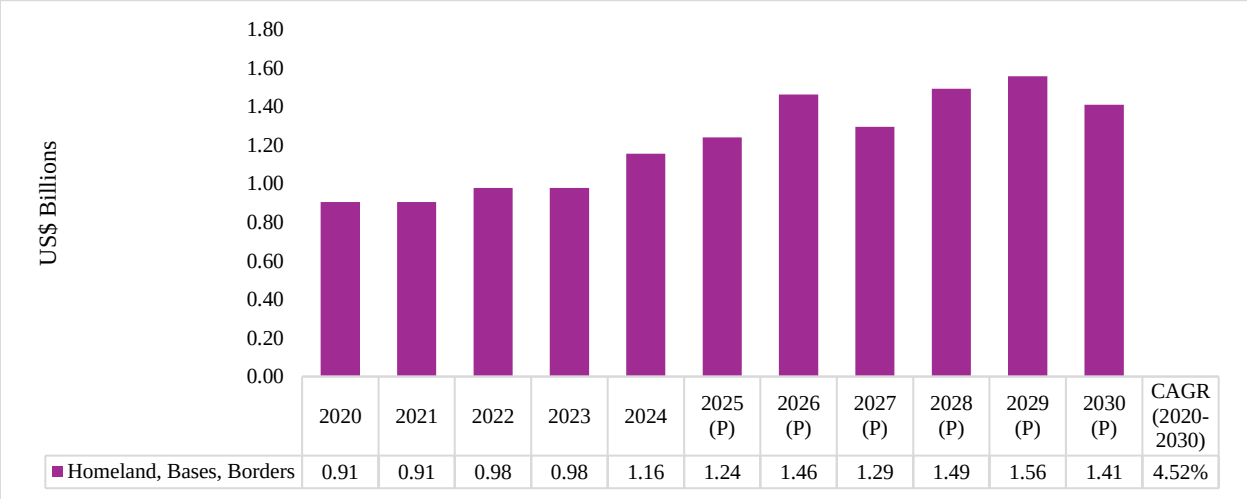
	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Tactical	2.62	2.62	2.62	3.38	3.36	3.27	3.57	3.53	3.53	4.40	4.30	5.09%

Source: Frost & Sullivan

- The tactical segment, spanning man-portable Electro-Optical/Infrared sights, soldier-borne systems, handheld multi-sensor target acquisition devices, remote weapon station optics, and vehicle-mounted reconnaissance turrets for light and special operations vehicles, represents the largest and most rapidly evolving category—growing from $2.62 billion in CY2020 to $4.30 billion by CY2030, at a CAGR of 5.1%.

7.4.5 Homeland Security, and Public Safety Applications

Figure 39: Electro-Optical/Infrared Market Forecast, Homeland Security, and Public Safety Applications, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Homeland, Bases, Borders	0.91	0.91	0.98	0.98	1.16	1.24	1.46	1.29	1.49	1.56	1.41	4.52%

Source: Frost & Sullivan

- The Homeland Security and Public Safety segment, including fixed and mobile Electro-Optical/Infrared platforms for perimeter security, base defense, border surveillance, critical infrastructure monitoring, and disaster response, is projected to grow from $906 million in CY2020 to $1.41 billion by CY2030, with a CAGR of 4.52%.
- The rise in non-traditional threats—drones, smuggling, and trafficking—has led to widespread adoption of Electro-Optical/Infrared sensors in homeland and dual-use roles.

7.5 Subsystems, OEMs, Integrators, and Service Providers

The Electro-Optical/Infrared industry involves a complex value chain from specialized component makers up to end-to-end solution providers. Key segments of this value chain include:

Table 19: Subsystems, OEMs, Integrators, and Service Providers Landscape

Subsystem Manufacturers	OEM	Integrators	Service Providers
• Lynred • SCD Semiconductor • Photonis	• Lockheed Martin • Raytheon Technologies • Thales Group • Elbit Systems • L3Harris WESCAM • Leonardo • Bharat Electronics Ltd • Tonbo Imaging • Paras Defense & Space	• Boeing • Hindustan Aeronautics Ltd • Larsen & Tuobro • Alpha Design Technologies	• L3 Harris WESCAM • Leidos • Bharat Electronics Ltd.

7.5.1 Subsystem Manufacturers

- Provide core building blocks: IR detector arrays, optical lenses, stabilization gyros, cryocoolers, lasers, and signal-processing electronics.
- Performance depends heavily on this tier: advances in detector sensitivity or optics directly elevate end-product capability.

- Global suppliers are limited (U.S., France, Israel), making this a strategic chokepoint.
- In India, subsystem production remains a gap—high-end FPAs and optics are mostly imported. DRDO initiatives are pushing domestic cooled FPA and thermal module development, though reliance on foreign vendors persists.

Table 20: Electro-Optical/Infrared Subsystem Value Chain. Source: Company Annual /Financial Reports

Company	Country	Sector	Electro-Optical/Infrared Offerings & Capabilities	Revenue (CY2024)	Export Presence
Lynred	France	Private	Designs cooled & uncooled IR detector subsystems (FPAs) across all IR bands. Europe's leading IR detector supplier for military, space, and surveillance applications.	USD 275 Million (2020)	Medium – Supplies IR detectors (e.g., VOx, MCT) to global OEMs; not direct system exporter.
SCD – SemiConductor Devices	Israel	Private (JV)	Produces medium- and high-wave IR detectors for defense, including long-range thermal vision sensors for aerial surveillance and missile warning. Fully integrated from R&D to packaging.	USD 32 Million	Low-Medium – India-based JV; emerging in exports, largely to select OEM partners.
Photonis	France/ Netherlands	Private	Global leader in image intensifier tubes (~70% of demand for Gen-3/4). Supplies NV tubes for goggles and scopes with auto-gating and high FOM for low-light imaging.	~USD 10 Million	Medium-High – Supplies night-vision tubes/detectors internationally through defense OEMs.

Source: Frost & Sullivan

7.5.2 OEMs (Original Equipment Manufacturers)

- Design and deliver complete Electro-Optical/Infrared systems: targeting pods, multi-sensor gimbals, weapon sights, handheld imagers.
- Global leaders: Lockheed Martin, Raytheon, Northrop Grumman, BAE Systems, Thales, Leonardo, Elbit, L3Harris, Teledyne FLIR.
- Focus areas: higher resolution, SWaP efficiency, AI-enabled analytics, and platform-specific customization.
- Some OEMs fabricate detectors in-house (e.g., Raytheon, Leonardo); others source from specialists (e.g., Lynred, Teledyne).
- In India:
  - BEL is the main state-owned OEM, producing IR sights, stabilized imagers, and turrets, often via JVs/tech transfers.
  - Tonbo Imaging and Alpha Design Technologies are emerging private players, offering indigenous, ITAR-free Electro-Optical/Infrared payloads for domestic and export markets.

Table 21: Electro-Optical/Infrared OEM Value Chain. Source: Company Annual /Financial Reports

Company	Country	Sector	Electro-Optical/Infrared Offerings & Capabilities	Revenue (CY2024)	Export Presence
Lockheed Martin	USA	Private	Provides Electro-Optical/Infrared systems across platforms. Develops suites like EOTS (F-35) and Sniper/XR pods, enabling long-range detection and targeting for fighters and helicopters.	USD 71.0 Billion	High – Supplies night-vision tubes/ detectors internationally through defense OEMs.
Raytheon Technologies	USA	Private	Supplies Electro-Optical/Infrared systems such as AN/AAS-52 MTS turrets and IR seekers. Advancing AI-enabled Electro-	USD 80.7 Billion	High – Wide export footprint for Electro-

			Optical/Infrared (RAIVEN architecture) for faster threat detection, with strong lifecycle support.		Optical/Infrared seekers, pods, targeting systems.
Thales Group	Italy/ USA	Government-linked	Produces integrated EO systems for land, sea, and air, incl. MIRADOR Mk2 surveillance turrets and Catherine thermal imagers. Emphasis on compact, modular systems for defense platforms.	USD 24.1 Billion	High – Extensive exports of Electro-Optical/Infrared systems across Europe, MENA, and Asia-Pacific.
Elbit Systems	Israel	Private	Wide Electro-Optical/Infrared portfolio: thermal sights, UAV payloads, targeting pods, night vision. Spectro XR and COMPASS turrets include AI-enhanced recognition and sensor fusion.	USD 6.8 Billion	High – Strong global presence in Electro-Optical/Infrared payloads and turret exports.
L3Harris WESCAM	USA	Private	Renowned for MX-series Electro-Optical/Infrared turrets (3,000+ fielded). Multi-sensor systems integrate HD thermal imagers, laser designators, and video tracking for air, maritime, and land Intelligence, Surveillance, and Reconnaissance (ISR).	USD 21.3 Billion	High – Exports MX-series Electro-Optical/Infrared systems globally.
Leonardo/ Leonardo DRS	Italy/ USA	Government-linked	Offers Electro-Optical/Infrared targeting and surveillance systems (IRST, thermal imagers, missile seekers). Recently secured U.S. Army contracts for Electro-Optical/Infrared sensors on SHORAD vehicles.	USD 20.7 Billion	High – Significant exports of naval, land, and airborne Electro-Optical/Infrared systems.

Company	**Country**	**Sector**	**Electro-Optical/Infrared Offerings & Capabilities**	**Revenue (FY2025)**	**Export Presence**
Bharat Electronics Ltd	India	Public (PSU)	India's primary Electro-Optical/Infrared OEM. Produces thermal sights, stabilized payloads, and naval EO fire-control systems (e.g., CoMPASS). Supplies targeting systems via partnerships and ToT.	INR 237,687 Million	Medium – Exports thermal systems regionally (e.g., to Nepal, African markets).
Tonbo Imaging	India	Private	Specializes in AI-enabled Electro-Optical/Infrared sensors and Intelligence, Surveillance, and Reconnaissance (ISR) payloads. Wolfpack TRST and Atlas offer 360° situational awareness with sensor fusion. Lightweight, low-SWaP solutions across domains.	INR 4,690 Million	Low-Medium – Indian OEM; some early exports, growing but still limited.
Paras Defense & Space	India	Private	Emerging Electro-Optical/Infrared OEM. Builds sights and gimbal systems (e.g., Sight-25HD). Supplies units for CIWS and space-grade optics. Growing export-linked programs with DRDO support.	INR 3,727 Million	Low–Medium – Emerging player with initial export-linked programs.

Source: Frost & Sullivan

7.5.3 Integrators

- Embed Electro-Optical/Infrared payloads into larger systems, ensuring seamless power, cooling, data, and C2 integration. Examples:
  - Aircraft OEMs (Boeing, HAL) fitting Electro-Optical/Infrared turrets into avionics.
  - Naval primes integrating Electro-Optical/Infrared into combat management systems.
- Big OEMs (e.g., Thales) often double as integrators, linking cameras with communications/C2 systems.
- In India:
  - DRDO leads during trials.
  - HAL and shipyards handle platform integration.
  - Specialized firms provide turnkey border surveillance systems, combining Electro-Optical/Infrared, radars, and command centers.

Table 22: Electro-Optical/Infrared Integrator Value Chain. Source: Company Annual /Financial Reports

Company	Country	Sector	Electro-Optical/Infrared Offerings & Capabilities	Revenue (CY2024)	Export Presence
Boeing	USA	Private	Integrates Electro-Optical/Infrared systems into aircraft and UAVs (e.g., L3Harris MX-20 on P-8A Poseidon, Lockheed M-TADS/PNVS on AH-64 Apache). Acts as a systems integrator ensuring fused Intelligence, Surveillance, and Reconnaissance (ISR), targeting, and mission avionics.	USD 66.5 Billion	Medium–High – Electro-Optical/Infrared exports tied to aircraft & weapon packages.

Company	Country	Sector	Electro-Optical/Infrared Offerings & Capabilities	Revenue (FY2025)	Export Presence
Hindustan Aeronautics Ltd	India	Public (PSU)	Integrates Electro-Optical/Infrared payloads on indigenous/licensed platforms (e.g., LCH, ALH Dhruv, Su-30MKI). Uses BEL CoMPASS turrets, Rafael Litening pods, and DRDO RST sensors. Collaborates on future fighters and UAV payloads under Atmanirbhar Bharat.	INR 304,000 Million	Low–Medium – Primarily domestic; limited exports (e.g., Myanmar Tejas).
Larsen & Tuobro (Hi-Tech and Defence)	India	Private	Integrates Electro-Optical/Infrared into naval/land systems, e.g., CIWS Sudarshan with 244 Sight-25HD sensors (Paras). Provides turnkey surveillance/targeting networks (radars + IR cameras + lasers). Supports indigenization goals.	INR 96,950 Million (approximate)	Low–Medium – Domestic focus, export potential via JV & govt. programs.
Alpha Design Technologies	India	Private	Specializes in Electro-Optical/Infrared integration for Indian Army vehicles (e.g., BMP-2, T-72, UAV payloads). Works with Elbit for thermal sights & fire-control systems. Provides lifecycle training & support. Increasing role in UAV/UGV programs.	INR 4,392 Million (approximate)	Low – Niche OEM; growing but limited exports.

Source: Frost & Sullivan

7.5.4 Service Providers

- **Scope of Services:** Includes OEM-led support (via maintenance contracts and service centers) and third-party contractors providing operations or analytics-as-a-service
- **Maintenance, Repair & Overhaul (MRO):** Essential for high-end Electro-Optical/Infrared gear, covering calibration, part replacement (e.g., finite-life cryocoolers), and software updates to sustain performance.
- **Global Service Networks**: Leading firms like L3Harris (WESCAM) operate authorized service centers worldwide for MX-series turrets, enabling local repairs, spare parts access, and technician training.
- **Localized Capability Building:** Regional service hubs enhance system uptime and foster self-reliance by training in-country experts for Electro-Optical/Infrared upkeep.
- **Operational Services:** Contractors may operate Electro-Optical/Infrared-equipped aircraft or UAVs for governments (e.g., in border surveillance or maritime patrol), delivering processed intelligence as the final product.
- **Data Analysis Services:** Niche providers use AI to process Electro-Optical/Infrared imagery (e.g., infrared satellite data) for defense, environmental monitoring, or geospatial intelligence applications.

Table 23: Electro-Optical/Infrared Service Providers Value Chain. Source: Company Annual /Financial Reports

Company	Country	Sector	Electro-Optical/Infrared Offerings & Capabilities	Revenue (CY2024)	Export Presence
L3 Harris WESCAM Service	USA	Private	Operates a global support network for WESCAM Electro-Optical/Infrared systems, with 13 dedicated facilities providing maintenance, training, and sustainment for military and law enforcement in 70+ countries. Focuses on maximizing operational uptime and through-life support of MX-series turrets.	USD 21.3 Billion	High – Exports MX-series Electro-Optical/Infrared systems globally.
Leidos	USA	Private	Provides "Intelligence, Surveillance, and Reconnaissance (ISR)-as-a-Service," offering aircraft with retractable Intelligence, Surveillance, and Reconnaissance (ISR) pods (e.g., MX-20) and analytics for surveillance missions. Handles sensor data processing, AI-driven analysis, and logistics, enabling clients to access Electro-Optical/Infrared intelligence without owning the hardware.	USD 16.7 Billion	Medium – U.S.-based integrator; exports via government sales, especially Intelligence, Surveillance, and Reconnaissance (ISR) platforms.
Bharat Electronics Ltd.	India	Public (PSU)	Alongside manufacturing, BEL provides MRO for Electro-Optical/Infrared systems under technology transfer agreements. Maintains D-level support for CoMPASS Electro-Optical/Infrared turrets, including repairs, spares, and training for Indian armed forces. Ensures availability of critical sensors in line with "Make in India" sustainment goals.	INR 237,687 Million	Medium – Exports thermal systems regionally (e.g., to Nepal, African markets).

Source: Frost & Sullivan

7.6 Impact of AI, Edge Computing, and Quantum Imaging on Future Growth

The Electro-Optical/Infrared industry is undergoing a structural shift as AI, edge computing, and quantum imaging redefine the design, deployment, and operational utility of imaging systems. These technologies are not incremental add-ons; they are force multipliers that transform Electro-Optical/Infrared from passive sensors into autonomous, intelligent surveillance and targeting ecosystems.

7.6.1 Artificial Intelligence

AI is revolutionizing Electro-Optical/Infrared by embedding autonomy, automation, and analytical depth into sensors. Defense primes and niche firms alike are integrating deep learning models (CNNs, transformers, GANs) to enable:

- **Automatic Target Recognition (ATR):** Neural networks trained on Electro-Optical/Infrared data rapidly classify and track targets (e.g., UAVs, vehicles, personnel), even in low-contrast or cluttered environments. This significantly reduces operator workload and compresses the sensor-to-shooter cycle.
- **Anomaly & Intent Detection:** AI baselines "normal" patterns in Electro-Optical/Infrared feeds and autonomously flags deviations, such as concealed vehicles or irregular troop movement, supporting predictive threat recognition.
- **Multispectral Fusion:** AI-enabled fusion integrates EO, IR, and multispectral bands into coherent outputs, cutting through fog, smoke, or camo to deliver clear situational awareness.
- **Semantic Scene Understanding:** Advanced AI parses every pixel to generate semantic maps, enabling mission-specific insights (e.g., auto-classifying ambush positions in urban terrain).

Operationally, AI is shifting control from human-in-the-loop to human-on-the-loop paradigms, where the machine performs data fusion and prioritization while commanders focus on confirmation and escalation. Frost & Sullivan estimates 40–45% of defense Electro-Optical/Infrared contracts by CY2030 will embed AI, compared to ~30% in 2024, making AI integration a baseline requirement rather than a differentiator.

Example: Israel's Rafael integrates ATR and semantic mapping into its targeting pods, while India's Tonbo Imaging co-develops AI-enabled missile seekers with Bharat Dynamics Ltd. to autonomously identify weak points on armored vehicles mid-flight.

7.6.2 Edge Computing and Distributed Systems

Edge processing is moving Electro-Optical/Infrared from passive collection to real-time decision-making nodes. By processing data at the sensor, systems reduce bandwidth requirements, avoid latency, and remain functional in GPS-denied or communication-contested environments.

- Embedded AI/SoC Hardware: Rugged low-power GPUs, ASICs, and FPGAs enable Intelligence, Surveillance, and Reconnaissance (ISR) drones, soldier-borne optics, and loitering munitions to autonomously classify and prioritize threats at the point of capture.
- Resilience in Contested Environments: Edge-enabled Electro-Optical/Infrared maintains Intelligence, Surveillance, and Reconnaissance (ISR) continuity even under EW, cyber disruption, or comms degradation.
- Distributed Mesh Intelligence, Surveillance, and Reconnaissance (ISR): Low-SWaP Electro-Optical/Infrared nodes connected in self-healing optical/radio networks allow persistent coverage, redundancy, and graceful degradation under attrition.

Example: The U.S. Army's IVAS program embeds edge AI in soldier helmets for real-time threat alerts; Tonbo Imaging's IIR seeker with BDL uses onboard AI and edge processors to adjust missile trajectories dynamically.

By CY2030, >35% of defense Electro-Optical/Infrared platforms are expected to feature embedded edge processors, compared to <15% in 2024. This will make edge autonomy a baseline design parameter for future Intelligence, Surveillance, and Reconnaissance (ISR) and targeting systems.

7.6.3 Quantum Imaging

Quantum imaging uses special photon properties and highly sensitive detectors to see in situations where traditional cameras fail. This includes seeing through smoke or darkness, detecting targets at long distances, and resisting jamming in ISR missions.

Quantum imaging remains at an early stage but has transformational potential for Electro-Optical/Infrared. Leveraging entanglement, single-photon detection, and quantum state manipulation, it promises imaging beyond classical limits:

- Ghost Imaging: Entangled photon pairs allow imaging even when only one beam interacts with the target, enabling vision in near-total darkness or through obscurants (fog, smoke, camouflage).
- SPAD Arrays: Detect extremely faint or long-range returns, enhancing Intelligence, Surveillance, and Reconnaissance (ISR) for covert surveillance and long-distance missile tracking.
- Spectral Upconversion: Transfers data from hard-to-detect IR bands to visible wavelengths, improving detectability of stealth platforms and camouflaged equipment.

Strategic Applications:

- Covert Ops: Near-zero illumination imaging for clandestine Intelligence, Surveillance, and Reconnaissance (ISR).
- Counter-Stealth: Detecting low-RCS aircraft or hypersonic vehicles by exploiting non-classical photon behavior.
- Resilient Intelligence, Surveillance, and Reconnaissance (ISR): Immune to conventional jamming/spoofing due to quantum correlation principles.

7.7 Threats and Challenges

7.7.1 Global Market Challenges

Despite the optimistic growth forecasts for Electro-Optical/Infrared systems, the industry faces several challenges globally.

Technical Challenges

- **SWaP vs. Performance Trade-offs –** Higher resolution/range increases size, weight, and cost (SWaP), conflicting with demand for compact, low-SWaP solutions.
- **Ruggedization Costs –** Military-grade reliability for extreme environments (temperature, vibration, shock) adds complexity and expense.
- **Specialized Manufacturing –** Thermal detectors, optical coatings, and gimbal assemblies require precision fabrication; defects cause delays and cost overruns.
- **Integration Complexity –** Multi-sensor, AI-enabled Electro-Optical/Infrared must integrate seamlessly with platforms, mission computers, and network architectures.

Business & Competitive Risks

- **High Entry Barriers –** New entrants face high R&D costs, long product qualification cycles, and stringent defense certifications.
- **Market Concentration –** Dominated by large OEMs; smaller firms struggle to compete without niche specialization or partnerships.
- **Supply Chain Vulnerabilities –** Dependence on limited-country suppliers; geopolitical tensions or export controls (ITAR/EAR) can restrict component flow.
- **Dependence on Rare Earth Metals -** Production of critical components for products is dependent on suppliers being able to procure raw materials, such as Germanium, Silicon and Carbon. Germanium is a scarce and expensive raw material and is subject to government licensing/export restrictions in certain geographies like China. Raw materials like Germanium and rare earth elements used in infrared optics are mined in only a few countries, such as China and Russia and face increasing scarcity and price volatility affecting the supply chain.

Operational Threats

- **Countermeasures Evolution –** Adversaries invest in camouflage, thermal masking, laser dazzlers, and decoys, forcing constant innovation.
- **Budget Volatility –** Defense Intelligence, Surveillance, and Reconnaissance (ISR) budgets can be cut or delayed due to economic downturns or shifting priorities.
  ROI Pressure – Programs increasingly require clear mission-impact justification for funding approval.

7.7.2 India-Specific Challenges

In India, the Electro-Optical/Infrared sector faces a unique set of challenges as it works to build indigenous capacity and reduce reliance on imports.

Dependency & Supply Risks

- High Import Dependence – Core technologies (InSb/MCT detectors, thermal camera cores, gimbals) still sourced from abroad, exposing India to supply delays, restrictions, and technology denial.
- Hybrid Sourcing Model – Indigenous capability still maturing; interim reliance on imports for critical components.

Procurement & Policy Barriers

- Bureaucratic Procurement Cycles – Long timelines and procedural inertia historically favored foreign OEMs over domestic innovators.
- Policy Execution Gaps – "Make in India" and DAP 2020 provide preferential policies, but contract awards and upgrade continuity remain inconsistent.

Funding & Market Size Constraints

- Capital-Intensive R&D – Detector fabs, cooled IR tech, and space-based sensors require sustained funding; private firms face capital access issues.
- Scale Limitations – Domestic market smaller than global peers, making exports necessary but highly competitive.

Industrial Base & Skills Gap

- Specialized Manufacturing Deficit – Gaps in precision optics, vacuum semiconductor processing, cryocoolers, and quality control capabilities.
- Testing Infrastructure Shortfall – Limited calibrated ranges and environmental test facilities for Electro-Optical/Infrared certification.

Operational & Environmental Factors

- Ruggedization Needs – Systems must withstand India's heat, dust, and humidity without performance degradation.

8 Precision Weapon Guiding Systems (PWGS)

8.1 Defining PWGS Systems

Precision Weapon Guiding Systems (PWGS) enable munitions to achieve meter-level accuracy by integrating advanced sensors, processors, and control mechanisms. Used across air, land, and naval platforms, they combine multiple guidance methods to ensure resilience in contested environments:

- **Inertial Navigation Systems (INS) –** Gyroscopes/accelerometers track position; immune to jamming but prone to drift, typically paired with GNSS for correction.
- **Satellite Navigation (GPS/GLONASS/NavIC) –** Provides global coordinate fixes; vulnerable to jamming/spoofing, mitigated by anti-jam modules.
- **Laser Guidance –** Semi-active laser homing for pinpoint accuracy; weather/LOS dependent.
- **Radar Homing –** Active or passive modes, including mmW radar for all-weather targeting.
- **Imaging Infrared (IIR) & Electro-Optical (EO) Seekers –** Visual/thermal lock-on with "fire-and-forget" capability; increasingly integrated with ATR algorithms.

Modern PWGS trends include sensor fusion (e.g., INS+GNSS+IIR), AI-enhanced ATR, and compact, modular seeker designs for cross-platform integration. These technologies underpin the shift toward precision-centric warfare, reducing collateral damage and improving cost-per-kill efficiency.

8.2 Market Sizing of PWGS

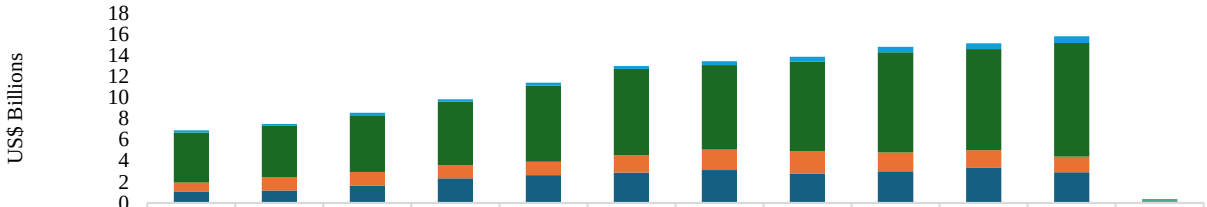
The PWGS market sits at the center of modern warfare transformation. Conflicts such as the Russia–Ukraine war and rising A2/AD threats have underscored the value of precision-guided weapons, from laser-guided bombs and GPS-enabled artillery shells to loitering munitions. Defense ministries now prioritize precision in procurement, integrating PWGS into both legacy and next-gen platforms.

The global market is forecast to grow from USD 9.35 billion in CY2020 to USD 20.58 billion by CY2030 (CAGR 8.2%). Growth is expected to accelerate through 2028, supported by expanded procurement programs, indigenous capability development, and AI-enabled targeting.

Key drivers across all markets include:

- Increasing shift from unguided to smart munitions for cost-effective, low-collateral operations
- High investments in PGMs such as smart bombs, air-to-ground missiles, loitering munitions, and artillery-guided projectiles – e.g., U.S. GBU-53/B StormBreaker and JDAM series, India's SAAW (Smart Anti-Airfield Weapon), Israel's Spike NLOS missile, and Turkey's MAM-L smart munition for UAVs.
- Integration of dual-mode guidance (e.g. INS + Electro-Optical/Infrared, or GNSS + laser) for flexibility across weather and battlefield conditions
- Advanced data-link-enabled weapons for mid-course corrections and networked targeting

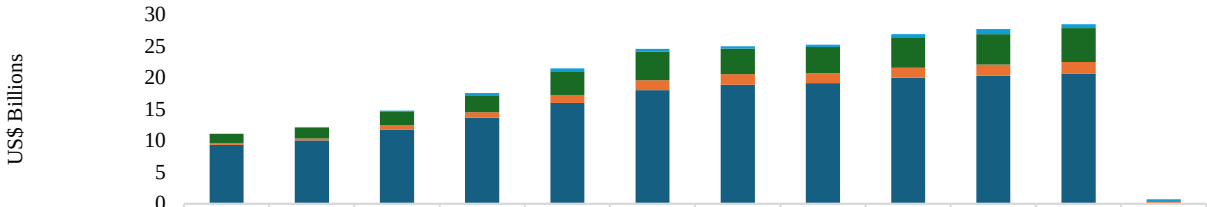
Figure 40:Precision Guided Weapon Systems Market Forecast, Target Markets, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
US	0.20	0.19	0.22	0.23	0.29	0.28	0.38	0.43	0.51	0.56	0.65	12.4%
NATO	4.73	4.86	5.39	6.06	7.25	8.22	8.03	8.53	9.52	9.61	10.79	8.6%
Middle East	0.87	1.29	1.31	1.24	1.26	1.62	1.94	2.14	1.80	1.63	1.48	5.4%
Asia Pacific	1.08	1.17	1.64	2.33	2.65	2.89	3.13	2.77	2.99	3.38	2.92	10.5%

Source: Frost & Sullivan

Figure 41: Precision Guided Weapon Systems Market Forecast, Global & Target Markets, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Growth Markets	0.05	0.12	0.22	0.38	0.47	0.43	0.34	0.35	0.58	0.78	0.60	27.3%
Europe	1.40	1.68	2.09	2.70	3.76	4.57	4.05	4.18	4.75	4.81	5.37	14.4%
India	0.29	0.33	0.71	0.86	1.26	1.54	1.66	1.54	1.55	1.81	1.89	20.6%
Global	9.35	10.04	11.74	13.63	15.98	18.01	18.88	19.13	19.98	20.27	20.58	8.2%

Source: Frost & Sullivan

8.2.1 Europe

- Europe's PWGS market is expected to grow from USD 1.40 billion in CY2020 to USD 5.37 billion in CY2030, at a CAGR of 14.4%—the fastest among developed regions.
- This surge reflects an aggressive pivot toward indigenous smart weapons programs in response to Russia's invasion of Ukraine and broader NATO push for technological sovereignty.

Key drivers include:

- France, Germany, and the UK are investing heavily in PGMs, missile upgrades, and smart artillery under joint frameworks like PESCO and the European Defence Fund – examples include France's AASM "Hammer" guided bomb upgrade, Germany's SMArt 155 sensor-fused artillery round, and the UK's SPEAR 3 and Brimstone missile enhancement programs.
- The EU's Future Combat Air System (FCAS) and Tempest programs emphasize AI-integrated PGMs and collaborative munitions.
- Growth in demand for indigenous Electro-Optical/Infrared and radar seekers for cruise missiles, glide bombs, and loitering drones.

8.2.2 India

- India's PWGS market is forecast to surge from USD 290 million in CY2020 to USD 1.89 billion in CY2030, translating to a CAGR of 20.6%.
- This expansion is fueled by growing investments in indigenous smart weapons, especially under the Atmanirbhar Bharat initiative, which mandates increasing localization of guidance systems.

Key drivers include:

- DRDO has accelerated development of Electro-Optical/Infrared and millimetric-wave seekers for BrahMos (supersonic cruise missile), HELINA (Nag-based helicopter-launched ATGM), SANT (stand-off anti-tank missile), and Astra Mk-II BVRAAM, alongside integration trials on Tejas and Su-30MKI platforms.
- Indian industry is increasingly participating in the development of guidance kits for converting gravity bombs into smart munitions (e.g. the Gaurav and Sudarshan laser-guidance kits).
- Growing exports to Southeast Asia and Africa for seeker-enabled systems (e.g. Pinaka rockets with guidance, BrahMos variants)

8.2.3 Growth Markets (Philippines, Indonesia, Nigeria, Morocco)

- PWGS demand in Growth Markets is expected to increase from USD 53.8 million in CY2020 to USD 603.1 million by CY2030, posting a robust CAGR of 27.3%—the highest among all regions analyzed.

Key drivers include:

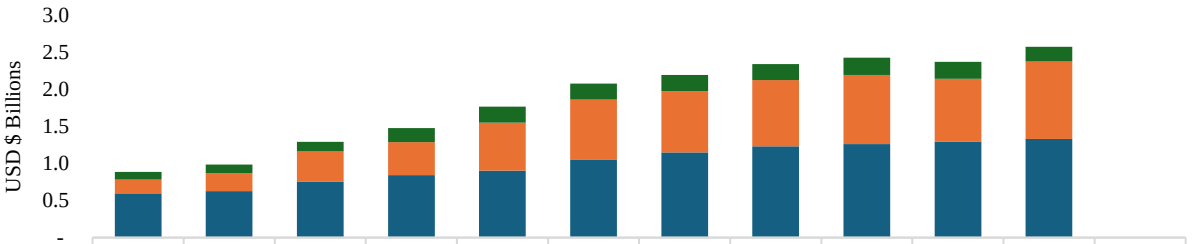
- Philippines and Indonesia are investing in air-launched and ship-launched guided weapons to assert maritime sovereignty amid South China Sea tensions.
- Nigeria and Morocco are acquiring precision-capable systems for counterinsurgency, border management, and deterrence, often through offset-linked defense deals with Israel, Turkey, or India.
- These markets are largely dependent on imports, but have begun exploring regional co-development and technology-transfer-based production (e.g., joint ventures in ship-launched missile systems and guided UAV munitions)

8.3 Platform & Munitions-Based PWGS Market Sizing (Global)

8.3.1 Platform-based PWGS

Platform-based PWGS are the guidance/targeting elements mounted on vehicles, aircraft, ships, and air-defense platforms—e.g., Electro-Optical/Infrared turrets, laser designators, rangefinders, fire-control computers, navigation/INS, and weapon-cueing/software. They generate tracks, designate targets, and close the fire-control loop for any weapon the platform carries.

Figure 42: Platform-based Precision Guided Weapon Systems Market Forecast, Global, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020-2030)
Naval	0.10	0.12	0.13	0.19	0.22	0.21	0.22	0.22	0.23	0.23	0.20	6.7%
Land	0.19	0.24	0.41	0.45	0.64	0.81	0.83	0.90	0.94	0.85	1.05	18.7%
Air	0.60	0.63	0.76	0.84	0.91	1.06	1.15	1.23	1.26	1.30	1.33	8.4%

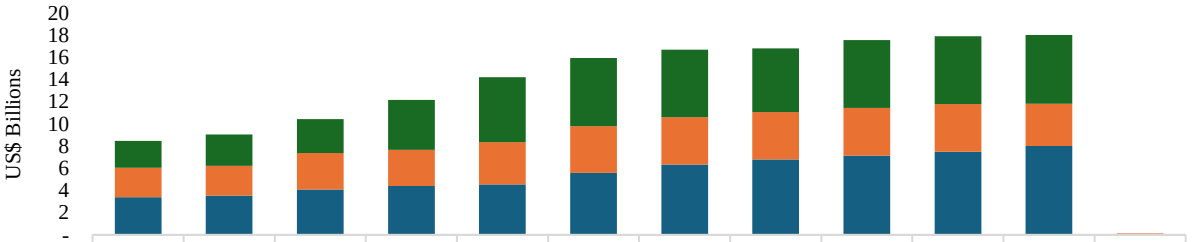
Source: Frost & Sullivan

- In CY2020, air-launched systems dominated the platform-based segment with ~67.4% share, a position projected to dip to ~51.5% by CY2030. This sustained lead reflects the premium value of air-delivered PGMs—cruise missiles, stand-off glide bombs, and guided rockets—integrated on manned fighters, UAVs, and next-gen air platforms. Demand is reinforced by fleet upgrades (e.g., F-35, Rafale, Su-30MKI), expansion of armed UAV inventories, and the shift toward long-range precision strike in contested A2/AD environments.
- Land-based systems accounted for ~21.3% in CY2020, climbing to ~40.7% by CY2030, the fastest proportional growth among platforms. Growth drivers include the surge in surface to air (SAM) air defense systems, guided artillery and rocket systems, ATGM modernizations, and precision strike missile programs in Europe, India, and select growth markets.
- Naval-launched systems represented ~11.2% in CY2020, moderating to ~7.8% by CY2030, with demand tied to anti-ship missiles, VLS-fired cruise missiles, and precision naval gun munitions linked to fleet recapitalization cycles.

8.3.2 Munitions-based PWGS

Munitions-based PWGS are guidance and control electronics inside the weapon itself—e.g., IR/RF/laser/mmW seekers, GPS/INS kits (JDAM-class), actuators, fuzes, and datalinks—turning bombs/rockets/missiles into precision-guided munitions.

Figure 43: Munitions-based Precision Guided Weapon Systems Market Forecast, Global, CY2020-2030



	2020	2021	2022	2023	2024	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2020 - 2030)
Naval	2.40	2.84	3.07	4.49	5.87	6.14	6.06	5.71	6.11	6.12	6.19	9.9%
Land	2.66	2.66	3.27	3.27	3.79	4.19	4.28	4.28	4.30	4.30	3.80	3.6%
Air	3.40	3.55	4.10	4.40	4.56	5.59	6.33	6.79	7.14	7.48	8.02	9.0%

Source: Frost & Sullivan

- Across munition categories, air-delivered PGMs—including glide bombs, air-to-ground missiles, and loitering munitions—lead consistently, growing from ~40.2% share in CY2020 to ~44.5% by CY2030. This growth is supported by multi-mode seekers, AI-enabled targeting, and the increasing load-out of small diameter bombs enabling higher sortie-level strike density.
- Naval munitions hold the second-largest share (~28.4% in CY2020 to ~34.4% in CY2030), buoyed by anti-ship and land-attack missile procurement, with continued investment in longer-range and sea-skimming profiles for contested littoral environments.
- Land munitions account for ~31.4% in CY2020, decreasing toward ~21.1%+ by CY2030, driven by the proliferation of guided rocket artillery, precision howitzer rounds, and land-based anti-ship/anti-air systems.

8.4 Key Growth Drivers and Potential Opportunities

Table 24: Key Growth Drivers and Potential Opportunities for PWGS Systems

Driver / Opportunity	Market Impact	Illustrative Examples	Indicative Adoption / Growth Outlook
Operational & Ethical Imperative for Surgical Precision	Expanding demand for PGMs in urban/complex environments; increased procurement priority in NATO, Indo-Pacific	• JAGM tri-mode seeker (SAL + GPS/INS + mmW radar) for all-weather accuracy • Spike/Javelin CLUs with man-in-the-loop safeguards	By CY2030, >85% of new tactical missile programs expected to include dual/tri-mode guidance for reduced collateral damage
Proliferation of Advanced Threats & Standoff Requirements	Accelerates long-range missile and glide bomb programs; drives seeker R&D for high-autonomy, high-resilience guidance	• HIMARS, naval cruise missile upgrades • Hypersonic programs (Mach 5+) requiring extreme-condition guidance	Long-range standoff PGMs to account for ~40% of total PGM spend in growth markets by CY2030
Miniaturization & Cost Reduction of Guidance Systems	Expands addressable market to artillery, mortars, UAV-class munitions; increases sortie-level PGM carriage	• 155mm PGK kits for artillery • GBU-69/B Small Glide Munition enabling multi-target strike per sortie	Sub-$20k guidance kits expected to see >15% CAGR, CY2024–CY2030
Modernization of Legacy Platforms	Creates retrofit market for Electro-Optical/Infrared sights, fire control, and targeting aids; low-capex path for capability uplift	• Thermal/night sights for small arms • Remote weapon stations with stabilized Electro-Optical/Infrared • Digital fire control for artillery	Retrofit Electro-Optical/Infrared & targeting systems projected at ~25–30% of Electro-Optical/Infrared & PWGS upgrade spend in emerging markets

8.4.1 Global Program Opportunities for PWGS

Table 25: Precision Guided Weapon Systems Program Opportunities

Country	Program Name	Budget	Timeline Expected	Contract Links
USA	Javelin ATGM	USD 7.2 billion (20,000+ units)	CY2023-CY2026	U.S. Navy Javelin Procurement Contract
Philippines	AIM-120 AMRAAM, GBU, AIM-9X	USD 5.6 billion (280+ units)	CY2025-Unknown	Armed Forces of the Philippines Missile Procurement

Morocco	FIM-92K Stinger Block I Missiles	USD 825.0 million (600 units)	CY2026-Unknown	Royal Moroccan Armed Forces Missile Procurement
Germany	Meteor BVRAAM	USD 567.9 million (150 units)	CY2025-Unknown	German MoD Meteor Procurement
Denmark	Naval Strike Missile	USD 196.0 million	CY2025-CY2030	Danish Navy NSM Procurement
Romania	Mistral MANPADS	USD 683.34 million (300 units)	CY2026-Unknown	Romanian Ministry of National Defence MANPADS Procurement
India	QRSAM	USD 4.32 billion	CY2028-CY2029	Indian Defense Ministry QR-SAM Procurement
India	BrahMos	USD 4.0 billion (200 units)	Unknown	Indian Defense Ministry BrahMos Procurement
India	VSHORAD-NG MANPADS	USD 3.24 billion (5,175+ units)	Unknown	Indian Armed Forces VSHORAD Procurement

Source: Frost & Sullivan Analysis

9 Directed Energy Systems (DES)

9.1 Defining DES Systems

Directed Energy Systems are weapons that emit highly focused energy to damage or destroy targets, as opposed to using physical projectiles. In essence, a directed-energy weapon (DEW) delivers a beam of concentrated electromagnetic radiation or subatomic particles at a target to cause effects ranging from sensor blinding and electronics disruption to structural burn-through. The main types of DEWs include High-Energy Lasers (HEL), High-Power Microwaves (HPM), and, to a lesser extent, particle beam weapons. Each operates on different parts of the spectrum, but all travel at or near the speed of light, enabling almost instantaneous engagement of targets.

- **High-Energy Lasers (HEL):** Precision burn-through for drones, missiles, small boats; limited by weather/atmosphere.
- **High-Power Microwaves (HPM):** Area-effect disruption of electronics; ideal vs. swarms, less weather-sensitive.
- **Particle Beams:** Experimental; extreme destructive potential but constrained by power and complexity.

9.2 Market Sizing of DES

The Directed Energy Systems (DES) market focused on Counter-UAS applications, especially High Power Microwave (HPM) systems, is undergoing an exponential growth phase as militaries worldwide seek cost-effective, scalable responses to the rising drone threat. The global DES market is expected to grow from USD 504.2 million in CY2025 to USD 3,818 million by CY2030, at a CAGR of 49.9%. This makes it one of the fastest-growing subsegments in the broader defense electronics domain.

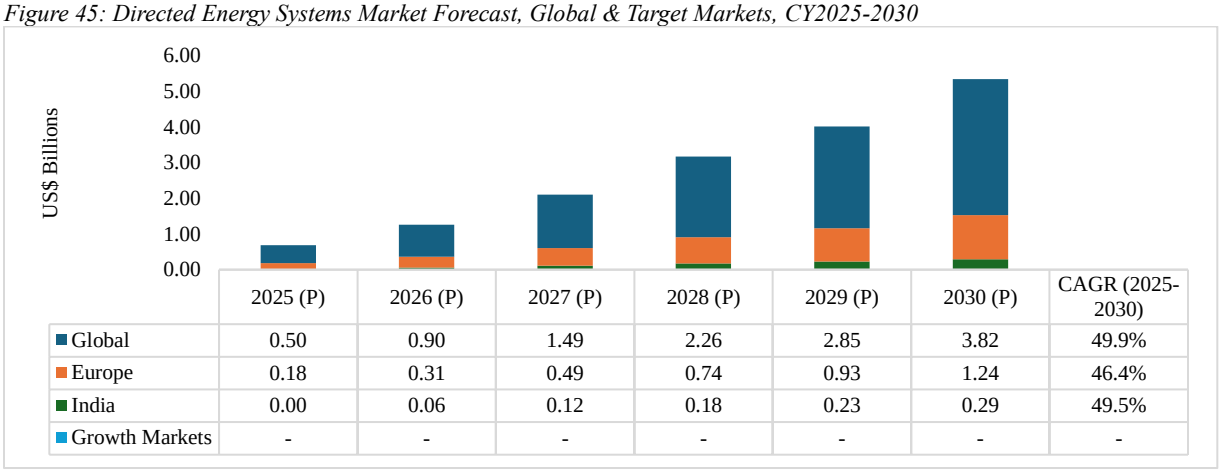
Figure 44: Design Image of Directed Energy Systems in Development

Source: Tonbo Imaging

The steep growth is attributed to:

- The proliferation of low-cost drones and drone swarms in asymmetric warfare and grey-zone conflict.
- Inefficiencies of using kinetic interceptors (e.g., missiles) against small aerial threats.
- The U.S. Department of Defense continues to lead investments in HPM technologies with platforms like THOR, PHASER, and Leonidas being tested and fielded.
- China's demonstration of HPM prototypes (e.g., Silent Hunter) signals intense competition in the domain.

Figure 45: Directed Energy Systems Market Forecast, Global & Target Markets, CY2025-2030



	2025 (P)	2026 (P)	2027 (P)	2028 (P)	2029 (P)	2030 (P)	CAGR (2025-2030)
Global	0.50	0.90	1.49	2.26	2.85	3.82	49.9%
Europe	0.18	0.31	0.49	0.74	0.93	1.24	46.4%
India	0.00	0.06	0.12	0.18	0.23	0.29	49.5%
Growth Markets	-	-	-	-	-	-	-

Source: Frost & Sullivan

9.2.1 Europe

- Europe's market is projected to grow from USD 184 million in CY2025 to USD 1,238.4 million by CY2030, reflecting a CAGR of 46.4%.
- European militaries are increasingly adopting DEWs as part of broader counter-drone architecture (C-UAS) in critical infrastructure and battlefield applications.
- Germany, the UK, and France are piloting field trials of microwave-based drone suppressors and laser-HPM hybrid systems.
- EU security strategy now considers drone incursions as high-risk threats to urban and border zones—leading to faster procurement cycles.

9.2.2 India

- India's DES market begins substantive growth from USD 58 million in CY2026 to USD 292 million in CY2030, yielding a CAGR of 49.5%.

- Recent RFIs by the Indian Army (for 90 HPM Mk-II systems) and Navy (for 40 long-range HPM units) indicate a clear roadmap for DES adoption, particularly for neutralizing drone swarms and loitering munitions.
- DRDO's Centre for High Energy Systems and Sciences (CHESS) is leading development efforts, with support from programs like DURGA II and indigenous laser platforms such as Mk-II(A) and Surya.
- Private sector players (e.g., Tonbo Imaging with WaveStrike, Adani Defence, BEL, Big Bang Boom Solutions, Paras Defence) are beginning to deliver field-deployable HPM and laser systems.
- DES platforms are being developed to operate across diverse terrains — from high-altitude Himalayan regions to deserts and coastal zones — reflecting India's broad security requirements.

9.2.3 Growth Markets (Philippines, Indonesia, Nigeria, Morocco)

- No measurable market activity or projections have been recorded for Growth Markets across CY2025–30, likely due to
  - Low defense R&D spending.
  - Prioritization of kinetic and conventional drone defense systems.
  - Lack of domestic capacity or procurement partnerships for DEWs or HPM integration.
- However, there may be latent demand post-CY2030 as DEW prices decline and off-the-shelf systems become viable through technology transfer or OEM leasing models.

9.3 DES Competitive Landscape

Table 26: DES Competitive Landscape - OEMs & Programs, Global

Country	Leading OEMs/ Integrators	DES Type	Flagship Program(s)	Power Class	Status	Export Potential
USA	Lockheed Martin, Raytheon, Northrop Grumman, General Atomics	HEL, HPM	HELIOS (USN), DE M-SHORAD (US Army), THOR (HPM)	50–300 kW	Operational trials	High
UK	MBDA UK, Leonardo UK, QinetiQ	HEL, RF	DragonFire Laser, RF Drone Defeat	50 kW+	Trials, naval & ground	Medium
Germany	Rheinmetall, MBDA Germany	HEL	Sachsen Frigate Laser Demonstrator	20–100 kW	Naval trials, scale-up planned	Medium
France/ Italy	MBDA, Thales	HEL	EDF Laser Defence Projects	20–60 kW	Demo stage	Low-Medium
China	NORINCO, CETC	HEL, HPM	LW-30 Truck Laser, Silent Hunter HPM	30–100 kW	Field deployments reported	Medium
Russia	Almaz-Antey	HEL	Peresvet Ground Laser	N/A	Claimed operational	Low
India	DRDO, BEL, Zetatek	HEL, HPM	Mk-II(A) 30 kW Laser, IDD&IS 2 kW	2–100 kW	Operational in anti-drone, scaling up	Medium
Israel	Rafael, Elbit Systems	HEL	Iron Beam	100 kW	Operationalization planned in CY2025	High

Source: Frost & Sullivan Analysis

9.4 Key Growth Drivers and Potential Opportunities

9.4.1 The Assymetric Threat and the Unfavourable Economics of Kinetic Defense

Militaries are facing a severe "cost-exchange ratio" problem. Using a multi-million-dollar interceptor missile, such as a Patriot or an AMRAAM, to destroy a commercial-grade drone that may cost only a few thousand dollars is a losing strategy. Adversaries, including non-state actors like the Houthis and near-peer competitors, can leverage this

asymmetry to deplete a nation's expensive and finite missile stockpiles through attrition. HPM weapons fundamentally break this economic model.

Examples of Developments:

- Raytheon's PHASER: This HPM system is designed specifically for base defense. It emits a cone of microwave energy to disrupt or destroy the guidance systems of multiple drones in its field of regard simultaneously, demonstrating the area-denial capability against swarms.
- Epirus's Leonidas: Utilizing solid-state Gallium Nitride (GaN) power amplifiers, Leonidas is a more compact and mobile HPM system that can be mounted on vehicles. Its ability to create a "force field" of microwave energy that can be precisely steered and scaled showcases the technology's growing sophistication and suitability for protecting mobile formations and critical infrastructure.

9.4.2 Unmatched Tactical Advantages: Speed, Scalability, and Non-Kinetic Effects

Beyond cost, HPM weapons offer a suite of tactical benefits that kinetic weapons simply cannot match, making them uniquely suited to the speed and complexity of the modern battlefield.

Analysis and Rationale:

HPM systems engage targets at the speed of light, eliminating the need for complex ballistic calculations to "lead" a target. The moment a threat is identified and targeted, the effect is instantaneous. This is a critical advantage against highly agile drones or coordinated swarm attacks where multiple threats must be engaged in seconds. Furthermore, HPM provides a scalable, non-kinetic effect. This has two key benefits:

- Area Effect for Swarms: A single HPM beam can be shaped to cover a wide area of the sky, neutralizing multiple drones in a single pulse, a task that would require numerous individual missiles.
- Reduced Collateral Damage: By disabling the drone's systems rather than blowing it up, HPM reduces the risk of shrapnel and falling debris causing unintended damage on the ground. This is crucial when defending sensitive or populated areas like airports, government buildings, or urban centers.

Examples of Developments:

- US Air Force's THOR (Tactical High-power Operational Responder): Developed by the Air Force Research Laboratory (AFRL), THOR is a containerized system designed for rapid deployment to protect airbases from drone swarms. Its primary design goal is to counter large numbers of drones with a single system.
- Vehicle-Integrated Systems: Numerous countries are now focused on integrating HPM emitters onto armored vehicles, such as Strykers in the U.S. Army. This provides a mobile air defense bubble for ground troops, protecting them from loitering munitions and reconnaissance drones while on the move.

9.4.3 Technological Maturity and the Global Race for Strategic Superiority

The pursuit of HPM technology is no longer theoretical; it has become a tangible and urgent global arms race. As the technology matures and proves its viability, nations are compelled to invest heavily in developing their own indigenous capabilities to avoid being left strategically vulnerable.

Analysis and Rationale:

For decades, the primary barrier to HPM was creating compact, efficient, and powerful enough systems for battlefield use. Recent breakthroughs in solid-state power amplification (e.g., GaN technology), advanced antennas, and pulsed power generation have finally overcome these hurdles, moving HPM from the laboratory to field-ready prototypes.

9.4.4 Global Program Opportunities

Table 27: Key Global DES Program Opportunities. Source: Frost & Sullivan

Country	Program Name	Budget	Timeline Expected	Contract Links
USA	Stryker DE M-SHORAD; IFPC-HEL; Epirus Leonidas HPM – 50-300 kW lasers; 10-20 MW HPM	USD 124 million	CY2024	U.S. Army HPM Procurement
Israel	Box Launcher & Mast-Mounted Laser – 100 kW Iron Beam; Microwave C-UAS	USD 500 million	CY2025-CY2026	Israel Defense Forces Procurement

India	4×4 Vehicle Mount; Future Naval/Air – 30 kW Mk-II(A) laser; 300 kW "Surya"	Undisclosed	FY2027	India - DRDO DES Development
Turkey	MRAP & Kaplan Hybrid Chassis - 20 kW ALKA Laser/HPM; ALKA-KAPLAN tank	Undisclosed	CY2024	Turkey - ROKETSAN DES Development
South Korea	Containerized/ Skynet Shelters – 20 kW Block-I "Skylight" Laser; Future Block-II	USD 72.5 million	CY2024	South Korea - Hanwha Aerospace DES Production
France	Sherpa-Light & Naval Mounts - 2-5 kW HELMA-P; 20 kW naval	Undisclosed	CY2024	French Armed Forces DES Procurement
UK	Type-45 Destroyer; Wolfhound HELWS – 50 kW DragonFire laser; RapidDestroyer HPM	Undisclosed	CY2027	UK Royal Navy DES Procurement
Germany	Sachsen F-124; Boxer IFV prototypes – 20 kW Naval LWD; 100 kW Rheinmetall Land Laser	Undisclosed	CY2028	German Navy DES Procurement

Source: Frost & Sullivan Analysis

10 Technology Trends: Observation, Understanding, Communication, and Offensive

10.1 Emerging Trends: AI-based Imaging, Sensor Fusion, and Edge Processing

The Russo-Ukrainian conflict and the Armenia–Azerbaijan standoff lessons have accelerated demand for real-time situational awareness, autonomous threat detection, and edge decision-making. Legacy sensors can no longer provide the speed, fidelity, or autonomy required in high-intensity, multi-domain operations.

10.1.1 Developments in AI:

AI is transforming Electro-Optical/Infrared and multispectral imaging into autonomous "intelligent surveillance" assets capable of detecting, classifying, and tracking threats in real time.

- **Object Detection & Tracking:** Deep learning models track vehicles, drones, and personnel with high accuracy, even under low light, clutter, or occlusion.
- **Anomaly Detection:** AI establishes baselines of normal activity and flags deviations — e.g., unexpected convoy movement or thermal spikes — critical for perimeter and urban monitoring.
- **Thermal & Multispectral Fusion:** AI integrates EO, IR, SWIR, and multispectral feeds into clearer composite outputs, enhancing visibility in fog, smoke, or night operations.
- **Semantic Scene Understanding:** Algorithms classify terrain and urban features down to pixel level, enabling commanders to rapidly identify threats, routes, and choke points.
- Edge Processing: Onboard AI deployed on UAVs, soldier systems, and armored vehicles reduces reliance on bandwidth-heavy links and ensures decision-making in GPS-denied zones.

10.1.2 Sensor Fusion Enhancing Situational Awareness

Sensor fusion integrates diverse modalities—Electro-Optical/Infrared, radar, LiDAR, sonar, acoustic—into a single operational picture. Each sensor's strengths compensate for others' limitations, providing all-weather, persistent Intelligence, Surveillance, and Reconnaissance (ISR).

- **Land:** Radar + Electro-Optical/Infrared enable real-time detection in urban combat zones despite obstacles.
- **Air/Naval:** Electro-Optical/Infrared paired with radar and acoustic sensors strengthens maritime and air defense surveillance.
- **Space:** SAR + multispectral imaging satellites enhance persistent reconnaissance across clouded or high-latitude regions.

10.1.3 Information Advantage from Edge Processing

Edge computing pushes analytics directly onto platforms—drones, armored vehicles, and soldier systems—delivering low-latency, autonomous decision support without relying on vulnerable communications.

- **Armored Vehicles:** Fuse Electro-Optical/Infrared, radar, and LiDAR for driver assistance, active protection, and target handoff.
- **Dismounted Troops:** Helmet displays provide real-time alerts, navigation, and targeting in denied areas.
- **Forward Operating Bases:** Onsite edge nodes maintain command capability during comms disruption.
- **Search & Rescue / CBRN:** Wearables detect heat signatures, chemical traces, or distress signals in hostile terrain.

10.2 Role of Imaging and Sensing in Modern Battlefield Scenarios

Imaging and sensing technologies now underpin OSIR (Observation–Surveillance, Imaging, and Reconnaissance), providing unmatched situational awareness and precise targeting across domains.

- **EO Imaging:** Provides high-resolution daylight reconnaissance for mission planning and post-strike analysis.
- **Infrared/Thermal Imaging:** Detects personnel, vehicles, and weapons through heat signatures, critical for night and obscured conditions.
- **SAR:** Delivers all-weather, high-resolution imaging for terrain mapping and wide-area surveillance.
- **Multispectral/Hyperspectral:** Identifies material properties, hidden equipment, and anomalies.
- **LiDAR:** Produces 3D maps for navigation, obstacle avoidance, and targeting in urban/complex terrains.

10.3 Adoption of Smart Sensors in Defence, Homeland and Border Security

Smart sensors combine Electro-Optical/Infrared, radar, acoustic, and environmental modalities with embedded AI and wireless networking, creating self-adaptive surveillance nodes.

- **Multi-Mode Sensorization:** Multi-spectral detection for full-spectrum threat awareness.
- **Edge Processing Integration:** On-device analytics enable immediate alerts, reducing reliance on central networks.
- **AI/ML Capabilities:** Pattern recognition and anomaly detection for autonomous response.
- **C4Intelligence, Surveillance, and Reconnaissance (ISR) Compatibility:** Seamless integration into command systems for joint operations.
- **Low SWaP Designs:** Lightweight, power-efficient builds suited to UAVs, soldier kits, and rugged deployments.

Applications:

- **Defense:** Real-time Intelligence, Surveillance, and Reconnaissance (ISR) from UAVs, UGVs, and soldier systems.
- **Homeland Security:** Urban surveillance, CBRN detection, and automated crowd analytics.
- **Border Security:** Electro-Optical/Infrared towers, vibration/acoustic fence sensors, and UAV-based Intelligence, Surveillance, and Reconnaissance (ISR) create integrated border-defense ecosystems.

Tonbo Imaging's low-power, modular Electro-Optical/Infrared platforms exemplify this shift, offering scalable, AI-enabled sensor payloads for defense and homeland use.

10.4 Understanding: Ranging, Target Acquisition, Machine Learning, etc.

Modern battlefield systems rely on laser ranging, target acquisition, and machine learning (ML) to deliver precision engagement and situational awareness in contested environments. Together, these technologies form the core of "Understanding" in the Observe–Orient–Decide–Act (OODA) loop, bridging raw sensor data with decision-ready intelligence.

10.4.1 Evolution of Laser Ranging System

Laser rangefinders (LRFs) have evolved over decades from basic distance measurement tools into networked, AI-enabled fire-control subsystems:

- **First Generation (CY1960s – Mechanical/Analog):** Early LRFs used simple optical and microwave principles to spot ranges up to a few hundred meters. They were bulky, slow, and used mainly for indirect fire support.

- **Second Generation (CY1970s–CY1990s – Digital Solid-State):** The advent of solid-state lasers and digital readouts allowed miniaturization. Systems achieved ranges of several kilometers, reduced response times, and became portable for frontline troops and armored vehicles.
- **Third Generation (CY2000s – Integrated Systems):** LRFs became part of integrated fire-control suites, fusing with Electro-Optical/Infrared sights, ballistic computers, and artillery command systems. They enabled multi-target tracking, ballistic correction, and real-time fire support, deployed across tanks, UAVs, and precision-guided munitions.
- **Fourth Generation (CY2010s–present – AI-Enabled & Networked):** Modern LRFs use MEMS-based scanning, eye-safe wavelengths, and AI-driven classification to map 3D environments. They adapt in degraded visual environments (fog, smoke, dust), feed directly into C4Intelligence, Surveillance, and Reconnaissance (ISR) networks, and enable cooperative targeting across platforms.

Example: India's DRDO is fielding AI-enabled LRFs on tanks and UAVs, while Israel and the U.S. deploy advanced "fused" systems in loitering munitions and airborne targeting pods.

10.4.2 Evolution Of Machine Learning (Target Tracking, Scene Classification) For Intelligence On The Battlefield

ML has transformed how defense systems process battlefield data, enabling real-time target detection, tracking, and scene understanding:

- **Early ML (Pre-CY2010s – Rule-Based):** Algorithms relied on template matching and background subtraction. They could identify vehicles or personnel but were slow, brittle, and dependent on large ground stations.
- **Deep Learning Era (CY2010s–present):** Advances in neural networks (YOLO, Mask R-CNN, SSD) enabled real-time object detection and multi-object tracking (MOT), even under occlusion, clutter, or poor visibility. Scene classification improved dramatically, allowing systems to differentiate terrain types (forest, urban, desert) and detect concealed or camouflaged assets.
- **Target Tracking Systems:** Modern ML systems use Kalman filters + deep learning to predict trajectories. Re-identification (Re-ID) networks ensure continuous tracking even if targets disappear briefly. Multimodal fusion (Electro-Optical/Infrared, LiDAR, radar) further improves accuracy.
- **Scene Understanding & Predictive Analytics:** Advanced models classify combat vs. civilian activity, detect IED placement through anomaly detection, and create 3D semantic maps using UAV or LiDAR data. This shortens decision cycles and improves rules-of-engagement compliance.

10.4.3 Integration into C4Intelligence, Surveillance, and Reconnaissance (ISR) and Fire-Control Workflows

ML is no longer standalone—it is embedded into C4Intelligence, Surveillance, and Reconnaissance (ISR) and fire-control systems:

- **Integrated Intelligence, Surveillance, and Reconnaissance (ISR)–Shooter Links**: ML-curated data flows directly into artillery fire-control, precision-strike munitions, and loitering drones, reducing human-in-the-loop delays.
- **Automated Alerts:** ML detects sniper fire, artillery launches, or unusual vehicle movement, generating alerts to commanders in seconds.
- **Cross-Sensor Fusion:** ML combines HUMINT, SIGINT, Electro-Optical/Infrared, and SAR into a single operational picture, improving accuracy while lowering analyst workload.
- **Mission Autonomy:** Autonomous UAV swarms can now classify, prioritize, and hand off targets among themselves without operator input — a direct result of ML-driven autonomy.

10.5 Communication: Long Range, Optical, etc.

Secure, resilient communication is the backbone of modern military operations. With Intelligence, Surveillance, and Reconnaissance (ISR), targeting, and C2 increasingly data-intensive, the ability to move high-bandwidth information across contested, degraded, or denied environments (CD2E) is now a decisive operational factor.

10.5.1 Limitations of Radio Frequency (RF) for Secure Long-Range Communication

Conventional RF-based tactical communications remain essential but face growing constraints:

- **Vulnerability to interception/jamming:** Omnidirectional propagation makes RF signals easily detectable and disruptable by enemy EW systems. Direction-finding and triangulation expose positions of command vehicles, UAVs, and FOBs.
- **Spectrum congestion:** Increasing military–civilian demand crowds HF/VHF/UHF bands, generating latency, collisions, and degraded reliability—especially in multinational or urban theaters.
- **Limited bandwidth:** RF is insufficient for modern Intelligence, Surveillance, and Reconnaissance (ISR) needs (e.g., live HD video, SAR imaging, or multi-sensor fusion feeds). Higher bands provide bandwidth but suffer from LOS/weather constraints.
- **Electromagnetic signature:** Persistent RF transmissions increase detectability, undermining stealth operations and survivability in EW-rich environments.

10.5.2 Evolution of Laser-based Free Space Optical (FSO) Communication for Secure High-Bandwidth Communication

Free space optical (FSO) communication leverages laser beams to deliver gigabit-class, interference-free data across line-of-sight (LoS) links.

Advantages:

- Multi-Gbps bandwidth, resilient to jamming/interception.
- Low probability of detection/intercept due to narrow beams.
- Spectrum independence — avoids Radio Frequency (RF) congestion since signalling used for communications is separate from traditional RF communications bandwidth.

Applications:

- UAV-to-ground/aircraft links: Real-time Intelligence, Surveillance, and Reconnaissance (ISR) and Command and Control (C2)
- Naval and FOB communications: Gigabit high speed data transfer between ships, coastal sites, and forward bases.
- Hybrid RF+FSO: Combines bandwidth and resiliency and allows redundancy in communications systems since RF signals may be degraded due to bad weather conditions.

Key developments include:

- Quantum Key Distribution (QKD) over FSO – enabling unhackable battlefield links, supported by AI-based adaptive optics and auto-tracking gimbals.
- By CY2030, FSO is projected to account for 25-30% of new tactical comms links in high-end militaties, supplementing but not fully replacing RF.

10.6 Offensive: Precision Targeting, Directed Energy Weapons, etc.

Modern offensive capabilities are evolving from mass-based kinetic dominance to precision, speed-of-light, and cost-efficient disruption. While missiles and smart munitions remain central, Directed Energy Weapons (DEWs) are emerging as scalable complements and substitutes.

10.6.1 Laser-Based Directed Energy Weapons (L-DEWs)

- **Mechanism:** High-energy lasers (HELs) deliver focused optical energy to heat/damage targets at light speed.
- **Advantages:** Instantaneous engagement, low cost-per-shot, scalable power levels, minimal collateral damage
- **Example:** Tonbo Imaging's T-Rex Electro-Optical/Infrared module provides precision tracking/stabilization for HEL targeting.

Use Cases:

- **Naval Defense (HELIOS, LaWS):** In the U.S. Navy, which uses ESPAs to address pirates or other small boats and suspected hostile drones, such as HELIOS (High-Energy Laser with Integrated Optical Dazzler and Surveillance) and LaWS (Laser Weapon System) fiber lasers are adapted to Electro-Optical/Infrared imaging and radar. Such lasers address threats swiftly and silently, particularly in swarm assaults or Intelligence, Surveillance, and Reconnaissance (ISR) drone penetration near ships.

10.6.2 Microwave-based Directed Energy Weapons

- **Mechanism:** Emit high-power electromagnetic pulses to disable electronics without physical destruction.
- The global DEW market is projected to grow from $504 million in CY2025 to $5.6 billion by CY2030 (CAGR >60%), with Israel, U.S., China, and India leading early deployment.

Use Cases:

- **THOR (Tactical High-Power Operational Responder):** It is a ground-based HPM weapon system developed by the U.S. Air Force Research Lab to face swarming drone threats. It can neutralise several small UAVs in one hit with no debris, and at relatively reduced risk of collateral area damage, with the system delivered in a single 20ft ISO container for easy use by forward operating bases or tactical convoys.
- **Airport or Urban Defense Systems:** HPM DEWs are beginning to be considered at field level deployment, also to be located near airports the urban areas where kinetic intercept (or laser) weapons have hazards to persons and hazards due to infrastructure. Their electronic-only capabilities provide a safe means of defeating rogue drones or Intelligence, Surveillance, and Reconnaissance (ISR) threats.

10.7 Value chain of Defence Ecosystem Globally and in India

The defence and aerospace ecosystem is not a linear supply chain but a multi-tiered value network, spanning policy, procurement, OEMs, integrators, subsystem suppliers, component manufacturers, and R&D partners. Each layer is interdependent, with feedback loops between user requirements, industrial capacity, and innovation pipelines.

10.7.1 Global Defence Value Chain

Nationally, the defense value chain is influenced by national security interests, strategic partnerships, and innovation directives. It is structured as follows:

Table 28: Global Defense Value Chain

Value-Chain Layer	Role & Responsibilities
Ministries of Defence/ Procurement Authorities	These entities define military requirements, allocate budgets, and oversee procurement processes. Examples include the U.S. DoD, NATO Support and Procurement Agency (NSPA), and Israel's IMOD.
Prime Contractors/ OEMs	Major defense companies such as Lockheed Martin, Thales, Boeing, and Raytheon design and provide complete defense platform aircraft, naval vessels, missile systems, and then serve as program integrators.
System Integrators	These players integrate several subsystems (such as optics, radars, communication modules) as a whole system. Traditionally, this work has also been carried out by OEMs, like Northrop Grumman and Saab.
Tier-1 & Tier-2 Subsystem Providers	These are OSATs whose services target niche applications such as firms like Teledyne FLIR, Elbit Systems, and Collins Aerospace, which supply Electro-Optical/Infrared sensors and targeting systems and advanced electronics for defence platforms.
Component and Equipment Manufacturers	Companies such as Analog Devices and Lynred, that provide thermal cores, sensors, power sources, and optics that make high-precision subsystems possible.
Software, AI, and Cybersecurity Providers	Defense-oriented firms such as Palantir, Anduril, and C3. AI delivers middleware for target tracking algorithms, AI-based Intelligence, Surveillance, and Reconnaissance (ISR) analysis, and secure communication systems.

Source: Frost & Sullivan

10.7.2 Indian Defence Value Chain

The Indian defense ecosystem is more or less a reflection of the global organizations, but has its palimpsestic policy initiatives for 'indigenization' under the Atmanirbhar Bharat vision:

Table 29: Indian Defense Value Chain

Value-Chain Layer	Role & Responsibilities
Ministry of Defence & Acquisition Bodies	There are institutions like the MoD, DRDO, DDP, and DAW that have the responsibility for defence procurement and capability planning. Innovation within the country is supported by frameworks like DAP 2020, iDEX, and Make-I/II.
Public & Private OEMs / Integrators	Public Sector, (HAL/BEL/BDL), etc, develop aircraft, electronics, missile systems.. The private sector role in platform development and strategic partnerships is growing with companies like Tata Advanced Systems, L&T, Mahindra Defence, Adani Defence, etc.
DRDO & Labs	India's apex R&D organisation, DRDO, and labs like IRDE, DARE are concentrating on developing indigenous technologies encompassing optics, EW systems, and AI-enabled warfare tools.
Tiered Suppliers	Companies like Tonbo Imaging operate at this level, providing Electro-Optical/Infrared imaging systems, target acquisition modules, and stabilized payloads integrated into UAVs, tanks, and surveillance systems.
Startups and MSMEs	With the support of schemes such as iDEX and TDF, an increasing number of Indian startups (eg, ideaForge, Big Bang Boom Solutions) are providing AI, autonomous systems, and sensor technologies.
Academic Institutions and Incubators	In line with this recommendation, Faculty members of IITs, IISc, and DIAT work with and for DRDO and Industry to include Quantum Sensing, Photonics, and Battlefield AI as next-gen technologies to research upon.

Source: Frost & Sullivan

10.8 Role of OEMs, System Integrators, and R&D Institutes

The defense industry functions as a tightly interlinked triad of OEMs, system integrators, and R&D institutes, each playing a distinct but interdependent role in capability development. Together, they define the "innovation-to-deployment pipeline" that underpins modern defense readiness.

10.8.1 Original Equipment Manufacturers (OEMs)

OEMs design, assemble, and deliver complete platforms and mission systems — from combat aircraft and UAVs to missile systems and naval vessels.

Global OEMs

- Lockheed Martin (U.S.): F-35 Joint Strike Fighter, HIMARS, Aegis Combat System.
- Airbus & Dassault (Europe): FCAS program, Eurofighter Typhoon, A400M transport.
- Rafael & Elbit (Israel): Spike missile family, Iron Dome interceptors, advanced Electro-Optical/Infrared suites.

Indian OEMs

- HAL: Combat aircraft (Tejas), helicopters (Dhruv, LCH), licensed production of Sukhoi and Hawk aircraft.
- BEL: Electro-Optical/Infrared systems, battlefield radars, C4I systems, EW suites.
- BDL: Missile production (Akash, Astra, ATGMs) with increasing indigenization.
- Tata Advanced Systems: UAVs, aerospace components, and Intelligence, Surveillance, and Reconnaissance (ISR) platforms via joint ventures with Lockheed Martin, Airbus, and Boeing.

10.8.2 System Integrators

Integrators ensure subsystems — Electro-Optical/Infrared payloads, radars, communication links, fire control systems — work together seamlessly on platforms or networks.

Global Integrators

- Northrop Grumman: Global Hawk Intelligence, Surveillance, and Reconnaissance (ISR) platform, IBCS (Integrated Battle Command System).
- BAE Systems: Battlefield digitization and EW-C2 integration.

- Thales: Naval combat management integration with Electro-Optical/Infrared, radar, and secure comms.

Indian Integrators
- BEL: Radar, missile command systems, and IACCS integration.
- L&T Defence: Naval and homeland security platforms, coastal surveillance networks.
- Alpha Design Technologies: Tactical Electro-Optical/Infrared and comms integration for Army/Air Force.
- Astra Microwave: Specializes in RF subsystems and tactical network integration.

10.8.3 R&D Institutes
R&D bodies inject technology foresight, IP, and prototyping into the value chain, enabling long-term capability development.

Global R&D Bodies
- DARPA (U.S.): Hypersonics, AI autonomy, electronic warfare innovation.
- Fraunhofer (Germany): Photonics, cyber resilience, radar and EO imaging.
- IMOD Labs (Israel): Electro-optics, UAV payloads, and multi-layered missile defense research.

Indian R&D Ecosystem
- DRDO & Specialized Labs:
  - **IRDE —** advanced EO systems and imaging seekers.
  - **DARE —** airborne EW and self-protection systems.
  - **LRDE —** 3D radars, AESA modules.
  - **DEAL —** secure datalinks, SDRs, quantum comms.
- **Academic Institutions:** IITs, IISc, and DIAT work on photonics, battlefield AI, and quantum sensing in partnership with DRDO.
- **Innovation Schemes:** iDEX, TDF, and Make-II programs connect startups and MSMEs with defense R&D projects.

10.9 Tonbo Imaging's Position in the Ecosystem
Tonbo Imaging is positioned as a recognized original equipment manufacturer (OEM) in the global defense and security ecosystem. With over 20,000 systems deployed across 24 countries as of March 31, FY2025, Tonbo offers a diverse suite of field-proven electro-optical solutions. Field-proven denotes systems that have been operationally validated in live combat and security environments, demonstrating reliability, durability, and mission effectiveness under real-world conditions. Unlike many competitors, Tonbo's products are free from export restrictions under the International Traffic in Arms Regulations (ITAR), enabling wider global deployment.

Globally, Tonbo's systems have been validated by customers in advanced defense markets—including the European Union, the United States, and Israel—underscoring their technical reliability, operational acceptance, and export competitiveness in some of the world's most demanding military ecosystems.

11 Tonbo Imaging Overview

11.1 Company Background and Evolution
Tonbo Imaging, founded by defense technology experts Arvind Lakshmikumar, Ankit Kumar, and Cecilia D'Souza, began by modernizing outdated night-vision systems. It rapidly expanded into the full electro-optical stack, combining optics, AI, and embedded computing to deliver vertically integrated, end-to-end situational awareness solutions. With over 20,000 systems deployed in over 24 countries as of FY2025 and no ITAR export restrictions, Tonbo Imaging is a trusted OEM helping armed forces worldwide achieve greater self-reliance in strategic imaging technologies.

Tonbo Imaging is a global defence electronics OEM, with a track record of design and delivery of field tested defence systems, designing and developing products primarily catering to military and armed forces across the globe. As of FY2025, Tonbo Imaging's products are used by more than 24 countries, serving entities such as the U.S. Navy SEALs,

Israeli Defense Forces, NATO, and the Indian Army. For its export achievements, Tonbo Imaging was recently awarded the Excellence in Tech Export Promotion – Medium Enterprises category at the HSBC Presents CNBC-TV18 SME Champion Awards event.

By applying computational imaging, AI, and sensor fusion, Tonbo Imaging build systems that are lighter, smarter, and significantly more cost-effective than conventional alternatives. This approach allows Tonbo to overcome limitations of traditional optics and infrared ("IR") sensors, embed edge AI in our systems for autonomous decision-making and deliver low-size weight and power ("SWaP"), high-performance platform systems across multiple domains.

11.2 Core Technologies and Product Portfolio

Tonbo's advantage lies in its proprietary IP portfolio spanning optics, infrared imaging, embedded computing, and AI-enabled control. The company expects to secure 10 approved patents by FY2026. Rather than relying only on hardware gains, Tonbo blends computational imaging, machine-learning software, and low-power electronics to deliver efficient, battlefield-ready autonomy.

In addition, defence procurement regulations favour domestic OEMs and system integrators in many countries. To navigate these markets, Tonbo supplies completely knocked down ("CKD") kits and electro-optic cores, allows white-labelling by local defence OEMs and ensures the final product qualifies as "domestically manufactured". Further, products assembled and branded locally can bypass restrictions related to defence offsets, import duties, or foreign procurement caps.

Tonbo Imaging's thermal weapon sight Spartan-S is a leading product in the defence technology industry. Benchmarked against comparable products in India, the Spartan-S is better in various features such as size, weight and power. For example, it is significantly smaller and lighter than competition, while offering better efficiency and performance.

Table 30: Peer Comparison of Tonbo Imaging's Thermal Weapon Sight

	Solution 1	Solution 2	Spartan-S	Remarks
Company Name	**Competition 1**	**Competition 2**	**Tonbo Imaging**	
Dimensions	~6" x 6" x 5"	~ 7" x 7" x 5"	4.3" x 2.3" x 2.3" / 4.3"x 2.9"x 2.3"	
Weight	~800g	~900g	280g	***< 300g is critical for interchangeable weapon and helmet sight.***
Power	18650 Lithium Battery (factory configurable)	18650 Lithium Battery (factory configurable)	CR-123/ 18650 Lithium Battery (factory configurable)	***Ability to work with both CR123 and 18650 is an advantage as it provides users with the flexibility to choose according to their operational requirements.***
Battery Life	>6 hrs with 18650 Battery (single battery)	>6 hrs with 18650 Battery (single battery)	> 2hrs with Cr 123 / > 8hrs 18650 Li Ion battery (single battery)	
Detection Range	~1000m	~1000m	1300m	

Available Laser	Not Available	Not Available	Near IR / Visible laser	**NIR lasers can illuminate targets which are not visible to the naked eye, allowing cameras with appropriate sensors to "see" scenes even when there is no thermal contrast.**
Image Storage	Not Available	Not Available	60 Snapshots / **8 Hrs Recording with 10k Snapshots**	
Calibration	Shutterless Operation; Manual Calibration	Manual Calibration	Shutterless Operation; Manual Calibration	
Adjustable OLED for Pixel Shift Zeroing	Not Available	Not Available	yes	
Shooters Remote	Not Available	Not Available	yes	
Flip-to-Side	Not Available	Not Available	Yes, 100% return to zero in clip on mode	***The ability to flip out and flip back in to maintain zero is critical on the battlefield***

Source: Frost & Sullivan Analysis

Global demand for Anti-Tank Guided Missiles (ATGMs) has surged in recent years, driven by evolving battlefield threats and the rapid replenishment needs seen across multiple conflict zones. Many countries—including India—continue to face persistent shortages as traditional supply chains struggle to keep pace with operational requirements. This has intensified the need for cost-effective, reliable, and easily maintainable seeker technologies, which form the heart of every ATGM system.

Missile seekers today are predominantly based on cooled infrared imaging systems, which, while effective, come with significant drawbacks: they are costly, incorporate complex mechanical cooling assemblies prone to failure, and are challenging to replace or maintain in the field. In contrast, uncooled infrared imagers offer a far more robust and economical alternative—they are lower cost, exhibit greater reliability, and provide longer operational life.

Tonbo Imaging's TRAP seeker fulfils these requirements. Engineered around an uncooled infrared imager, TRAP leverages Tonbo's proprietary advances in optics technology and sensor design to deliver performance that matches the requirements for modern ATGMs.

Table 31: Peer Comparison of Tonbo Imaging's Infrared Missile Seeker

Key Parameters	Competition 1	Competition 2	Tonbo Imaging's Solution
Imager Type	Cooled MWIR	Cooled MWIR	Uncooled LWIR
Operational Range	4 km	4 km	4 km

Mean Time Between Failures	10,000 hours	10,000 hours	40,000 hours
Weight (of the imager)	800g	1 kg	< 100g
Power consumption	5 watts	8 watts	< 2 watts
Cost (US $)	$$$$$	$$$$$	$$

Source: Frost & Sullivan Analysis

In addition to technologies mentioned above, a notable development is Tonbo Imaging's development of HPM systems which has potential ability to take down large swarms of enemy drones. This is a clear and modern-day threat and every nation wants to own sovereign capabilities in this space.

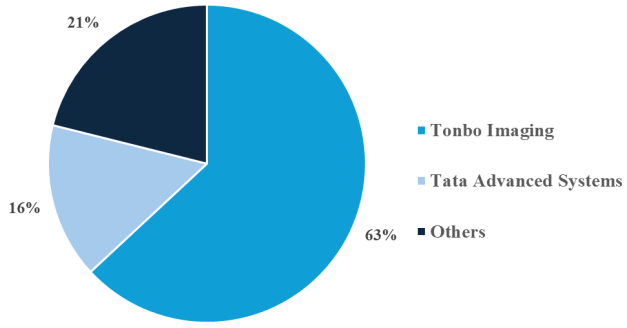
11.3 Key Competitive Advantages

Tonbo Imaging's key technology developments are in advanced optics, AI-enabled imaging, and embedded systems. The company develops small, tough lens assemblies, including aspherical, reflective, and compound lenses optimized for visible, IR, SWIR, and thermal applications. Using machine learning, Tonbo offers real-time target detection, behavior prediction, and multi-sensor fusion (Electro-Optical/Infrared/SWIR/Radar) for improved situational awareness. Its edge-computing features are supported by low-SWaP-FPGA-ARM-based platforms, which significantly help in lowering latency and bandwidth requirements.

Developed markets like the US and Israel set the benchmark for technological superiority and emerging markets like India, Southeast Asia and Africa are price sensitive. Tonbo Imaging design their products baselining their technology with developed markets and pricing them competitively for developing markets.

Tonbo Imaging's is a key supplier of thermal imaging systems to India. This can be seen from its success in winning various Indian government tender opportunities.

Figure 46: Market Share (Units) of Thermal Imaging Systems Supplied to India Government, April 2022 to March 2025



Source: Frost & Sullivan, India Government e-Marketplace

Over the period of April 2022 to March 2025 Tonbo Imaging is the largest manufacturer, in terms of sales value, of thermal imaging systems to government and defense agencies in India.

11.4 Program Opportunities for Tonbo Imaging

With the Technology Perspective and Capability Roadmap (TPCR-2025) release, India's armed forces are placing strong emphasis on directed-energy weapons, advanced unmanned systems, AI-enabled sensors and imaging for Intelligence, Surveillance, and Reconnaissance (ISR), and anti-swarm, counter-drone capabilities — areas in which Tonbo Imaging's low-cost optics and computational imaging technologies are especially relevant.

Tonbo's future potential lies in becoming a key supplier to address the opportunities highlighted in the roadmap by localising high performance imaging hardware, integrating AI for targeting and detection, participating in joint development of RCWS (Remote Controlled Weapon Systems), and supporting deployment of sensors for space, aerial, and ground-based unmanned platforms.

Table 32: Indian MoD Program Opportunities

Program Name	Program Brief	Quantity
Future Ready Combat Vehicle (FRCV)	360° panoramic commander/gunner Electro-Optical/Infrared, day–night driver vision.	1,700-1,800 nos
Driver Night Sights	Uncooled thermal + low-light monocular for driver situational awareness.	3,000-3,200 nos
Night Vision for Gunner & Commander for BMP-2	Panoramic commander sight with Electro-Optical/Infrared; gunner day/night Fire Control System (FCS).	2,000-2,200 nos
Stealth RPAs	UAS with low-observable comms and SIGINT/Intelligence, Surveillance, and Reconnaissance (ISR) payload options.	55-70 nos
Special Optical Payload	Multi-aperture Electro-Optical/Infrared package enabling wide-area coverage from a single gimbal.	Not disclosed
Integrated Surveillance and Targeting System (ISAT-S)	Integrated Intelligence, Surveillance, and Reconnaissance (ISR) + precision targeting suite for vehicles and towers.	700-800 nos
Unmanned Aerial Vehicle Launched Precision Guided Missiles (ULPGMs)	Lightweight Electro-Optical/Infrared-guided munitions for armed UAS.	350-400 nos
4th/5th Generation ATGM	Dual-mode seeker; fire-and-forget / top-attack capable.	20,000-50,000 nos
Anti-Tank Guided Missile (ATGM)	Gen-3/4/5 gun-launched missile integration for MBTs.	20,000-50,000 nos
Thermal Imaging (TI) Sights	Clip-on thermal/II sights for small arms and MGs.	55,000-60,000 nos
Image Intensifier Sights	Gen-3+ NV weapon sights for infantry units.	180,000-200,000 nos
Helmet-Mounted NVBs	Sub-1 kg NV binoculars; water-/weather-proof; helmet-mountable.	Not disclosed
IR Seeker and Accelerometer	IIR seeker with high-G survivability and precision IMU.	5,000-5,500 nos
Electro-Optic Infrared Search and Track system (EOIRST)	Passive Electro-Optical/Infrared search-and-track for air/sea targets under zero-vis conditions.	100 nos
Long Range EO Sensors	Multi-sensor (LLTV/IR/telephoto) package for helicopter/UAV/MR aircraft.	200 nos
Laser-Based Communication System	Tactical FSO link for secure, high-throughput two-way connectivity.	30-40 nos
Stratospheric Airship	High-altitude relay for comms and wide-area SIGINT/Intelligence, Surveillance, and Reconnaissance (ISR).	20 nos

Hybrid RPA	Short-range VTOL/convertible UAS for 200 km missions and hover Intelligence, Surveillance, and Reconnaissance (ISR).	10-20 nos
EOIRST on Fighter Aircraft	Fighter-class passive Electro-Optical/Infrared detection, tracking, and ranging suite.	> 70 nos
Smart Loitering for BVLOS Munitions	Ground-launched loiterers with Electro-Optical/Infrared seeker and 6+ hr endurance.	200-500 nos
Advanced Driver Assistant System (ADAS) for Heavy Vehicles	AI-enabled optical/RADAR/LiDAR driver-assist and warning functions.	1,200 nos
High Power Electromagnetic Weapon System	Mobile HPM for wide-area electronics defeat at 6–8+ km.	< 10 nos
Targeting Pods– > 100 nos	Day/night pod with laser designator and Electro-Optical/Infrared tracker for LGB/EO weapons.	> 100 nos
Next-Generation Night Vision Devices (IR/Thermal Imaging)	Handheld day/night detection and recognition of small targets.	Not disclosed
Helmet Mounted NVBs – Undisclosed nos	Sub-1 kg helmet NV; detection/ID in pitch-dark conditions.	Not disclosed
Dual IR Band and UV-Based Imaging Seekers for MAN Portable AD System	Multi-band seekers to defeat flares; >12 km target ID.	1,200 nos
Augmented Reality Helmet for Ground Troops	Helmet display with AI/ML overlays and blue-force awareness.	14,000 nos
Hard Kill Counter UAS System	Vehicle-mounted C-UAS with RF/AESA/EO&IR sensors and neutralizers.	< 225 nos
Directed Energy Weapon	HEL/HPM system for counter-drone and air-defense roles.	Not disclosed

Source: Ministry of Defence, India TRCP-FY2025

12 Operational and Financial Benchmarking

Tonbo Imaging is a global defence deep tech company that specializes in high performance imaging, processing, communication and control systems with the primary incentive to facilitate autonomy in complex environments. With proven technology in advanced military, aerospace electro-optics and imaging systems, Tonbo Imaging's portfolio provides leading size, weight, cost and performance benefits.

To assess Tonbo Imaging's positioning within both the Indian and global defence electro-optics (Electro-Optical/Infrared) landscape, it is essential to benchmark against companies that operate in closely related domains and demonstrate comparable technological relevance. The selected global companies—Epirus (US), Teledyne FLIR (US), Hensoldt (Germany), Theon International, and Controp (Israel)—represent established players in Electro-Optical/Infrared, thermal imaging, and advanced defence electronics. They provide a meaningful reference for evaluating technology integration, global market penetration, and intellectual property ownership. Similarly, the Indian defence companies chosen for comparison—Astra Microwave, Zen Technologies, Data Patterns, Paras Defence, and Bharat Electronics—are leading domestic peers in defence electronics, radar, simulation, and subsystem integration. Together, these companies represent the relevant ecosystem within which Tonbo Imaging operates and highlight the gaps Tonbo fills by offering proprietary, end-to-end Electro-Optical/Infrared subsystems.

12.1 Profiling of Key Global and Indian Competitors

This section provides a brief overview of each selected company, outlining their core business areas, market presence, and relevance within the defence and Electro-Optical/Infrared ecosystem.

Table 33: Profiles of Key Global and Indian Competitors

Company	HQ	Description	Product Portfolio	Geography Mix for FY25 Revenue	Revenue (FY25)	Electro-Optical/ Infrared Presence
Astra Microwave	Hyderabad, India	Indian designer/ manufacturer of RF, microwave & digital electronics for defence, aerospace & space; strong on indigenization & system integration.	Radar subsystems, missile electronics, SATCOM RF, RF/microwave modules, integrated EW/comm subsystems.	India ~90%, Exports ~10%	INR 10,512 Million	Indirect/ Adjacent (sensor electronics, radar RF); limited direct Electro-Optical/ Infrared payloads.
Zen Technolog-ies	Hyderabad, India	Indigenous training simulators & anti-drone systems; growing autonomy & surveillance capabilities.	Weapon & vehicle simulators, live/virtual training ranges, C-UAS systems, surveillance solutions.	India ~62% Exports ~38%: Middle East, Africa, CIS, North & Latin America, UAE.	INR 9,736 Million	Limited/ Enabler (C-UAS integration of Electro-Optical/ Infrared as part of systems).
Paras Defense	Navi Mumbai, India	Veteran optics/EO player across defence & space; strong in electro-optics & EW subsystems.	Opto-electronic systems, submarine periscopes, drone payloads/gimbals, rugged avionics, space optics.	India ~85% Exports ~15%: Israel, USA, Europe, South Korea, Singapore, UAE, Saudi Arabia, South Africa, Canada.	INR 3,647 Million	Strong (EO lenses/ assemblies, gimbals, periscopes, payloads).
Data Patterns	Chennai, India	High-reliability defence/aero electronics across full lifecycle	Radar electronics, avionics LRUs, SATCOM/ command systems, embedded control & test systems.	India ~85% Exports ~15%: Europe & East Asia.	INR 7,084 Million	Indirect/ Adjacent (radar/ optronics electronics; limited proprietary Electro-Optical/ Infrared).

Bharat Electronics Ltd.	Bengaluru, India	MoD Navratna PSU; leading defence electronics across radar, EW, comms, EO, avionics, cyber.	Radars, EW/ESM, comms, EO/thermal imagers, avionics, C2, air defence, coastal security systems.	India ~96% Exports ~4%; Make in India-led footprint.	INR 237,688 Million	Strong (thermal imagers, sights, optronics suites).
Tata Advanced Systems	Hyderabad, India	Tier-1 aerospace & defense OEM under Tata Group; airframes, missiles, radars, composites, and systems integration	aircraft structures, UAVs, missile subsystems, radar & EW modules, C4ISR integration; build-to-print for global primes	India + exports (U.S./EU/ Israel) via OEM partnerships	INR 51,231 Million (approximate)	Indirect/ Adjacent (Electro-Optical/Infrared integration on platforms; limited proprietary Electro-Optical/ Infrared product)
VEM Technologies	Hyderabad, India	Indigenous weapons & avionics house; strong in seekers, propulsion, guidance, and test equipment	ATGM subsystems, seekers & IMUs, rocket motors, launchers, avionics, test stands; missile integration	India (MoD/ DRDO programs); selective exports	Not disclosed	Strong (seekers/IMUs; Electro-Optical/ Infrared terminal guidance, test gear)
Epirus	Los Angeles, USA	Deep-tech defence firm focused on high-power microwave (HPM) directed energy (Leonidas).	HPM C-UAS systems (Leonidas family), AI-driven power electronics; platform integrations.	Primarily U.S.; scaling to Army/Navy platforms; allied expansion underway.	Not disclosed	None/Minimal (focus is HPM, not Electro-Optical/Infrared).
Teledyne FLIR	Wilsonville, USA	Global leader in thermal/IR sensors & systems; multi-domain sensing & small UAS.	Thermal cameras/cores, night vision, Black Hornet nano-UAS, UGVs (via Endeavor), surveillance payloads.	Global (defence, industrial, commercial).	USD 5.3 Billion (CY24)	Very Strong (broad Electro-Optical/ Infrared product stack across sizes & markets).

Hensoldt	Taufkirchen, Germany	European sensor champion across radar, EW & optronics; ISR & situational awareness systems.	Air/ground/sea radars, Electro-Optical/ Infrared sights, optronics, EW, mission systems, surveillance suites.	Europe/ NATO + global exports; key supplier to German Military.	USD 2.4 Billion (CY24)	Strong (optronics & Electro-Optical/ Infrared suites for land/air/sea).
Theon Internation-al	Koropi, Greece	Customized night vision & thermal imaging; vertically integrated; 71-country footprint.	NVGs, thermal weapon sights, clip-ons, binoculars/ monoculars, fused sensors; soldier systems.	Global: 71 countries (incl. 26 NATO); EU/US/ME/ Asia presence.	USD 352.4 Million (CY24)	Strong (NV/TI product lines; soldier optronics).
Controp Precision Technolog-ies	Hod HaSharon, Israel	Specialist in stabilized Electro-Optical/ Infrared gimbals & precision motion-contro l systems.	Electro-Optical/ Infrared cameras & gyro-stabilized gimbals for UAV/UGV/ ship/ground; border/coastal/H LS suites.	Global; incl. U.S. subsidiary (Virginia) supporting U.S. market	Not disclosed	Very Strong (stabilized gimbals & turnkey Electro-Optical/Infrar ed surveillance).

12.2 Strategic Comparison

12.2.1 Indian Peer Comparison

Table 34: Indian Defense Peer-Level Comparison

Defense Players	Business Model	Product Range	Value Proposition	Export % of Revenue (FY25)
Tonbo Imaging	Horizontally integrated; in-house design & IP ownership, outsourced manufacturing	Full-stack Electro-Optical/Infrared with proprietary subsystems	Owns 100% Electro-Optical/Infrared IP, modular + miniaturized systems	65.52%
Astra Microwave	Product company for RF subsystems; contract-based manufacturing model	No direct Electro-Optical/Infrared systems	RF subsystems; Electro-Optical/Infrared limited	10.00%
Zen Technologies	Software-focused; builds simulation platforms with integrated third-party systems	Electro-Optical/Infrared used in simulators only	Software-led training, light integration of Electro-Optical/Infrared	37.97%
Paras Defense	Manufacturing-led with partial design capability; relies on technology partnerships	Electro-Optical/Infrared payloads but reliant on partners	Manufacturing capability, relies on OEMs	14.59%

Data Patterns	Vertically integrated; strong in embedded systems, low Electro-Optical/Infrared design ownership	Supports Electro-Optical/Infrared via backend electronics	Control systems, not optical payloads	15.00%
Bharat Electronics	Vertically integrated PSU; extensive in-house production, limited IP independence	Limited Electro-Optical/Infrared, mostly integrated systems	General systems integrator, relies on partnerships	3.86%
Tata Advanced Systems	Vertically integrated, manufacturing-led system integrator; Tier-1 platform/OEM partner for Electro-Optical/Infrared payload integration.	Electro-Optical/Infrared integration, and co-development with BEL for cooled-MWIR (limited proprietary Electro-Optical/Infrared).	General systems integrator, relies on partnerships.	Not disclosed
VEM Technologies	Manufacturing-led with in-house design; missile-subsystems house specializing in Electro-Optical/Infrared seekers and guidance electronics.	Electro-Optical/Infrared seekers; seeker processors; strap-down IMUs/autopilots; launcher & fire-control electronics; seeker ATE/test stands.	Indigenous seeker + navigation IP; high-G-qualified	Not disclosed

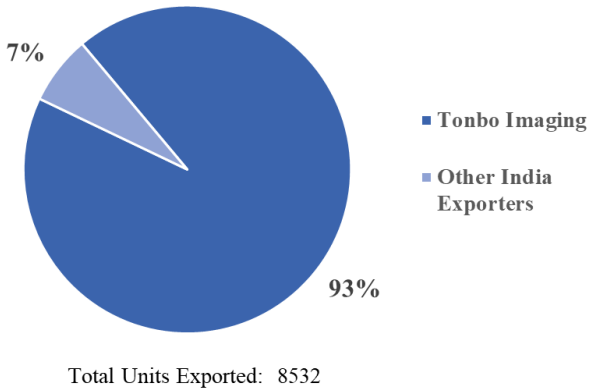
Source: Frost & Sullivan

Many major Indian defense firms, such as Bharat Dynamics Limited (BDL) and Hindustan Aeronautics Limited (HAL) collaborate with foreign technology partners like MBDA Missile Systems and Elbit Systems for critical missile, radar, and unmanned aerial vehicle (UAV) subsystems through joint ventures and technology transfers. These collaborations often involve licensed production and integration of externally developed seekers, sensors, or engines, underscoring demand for foreign technical know-how.

In contrast, Tonbo Imaging is one of few companies in India with no dependence on external technology partners as it owns 100% of its intellectual property, from optics to embedded software and electronics including critical subsystems for sighting systems, including proprietary video engines, AI-accelerated image processing, and sub-5 µrad multi-axis gimbal stabilization.

Tonbo also leads in export performance, with 65.52% of FY25 revenue from overseas markets, far surpassing Data Patterns (~15%), Zen (~38%), and others in FY25. This positions Tonbo Imaging as the supplier with the highest % of revenue from exports among the listed defence peers in FY25. Tonbo Imaging's growth has been fueled by private capital and self-funded R&D, unlike many domestic peers, underscoring its position as a capital-efficient, globally validated innovator in modern Electro-Optical/Infrared technologies. In addition, Tonbo Imaging accounted for 93% of India's thermal imaging export volumes, making it the country's largest exporter of thermal imaging systems by units shipped in FY24 and FY25.

Figure 47: Market Share (units) of Thermal Imaging Exports from India, April 2023 to March 2025



Source: Frost & Sullivan, Customs Data

12.2.2 Global Defense Peer Comparison: Business Models, Capabilities, and Export Strength

Table 35: Global Defense Peer Level Comparison

Defense Players	Business Model	Product Range	Value Proposition	Global Presence
Tonbo Imaging	Horizontally integrated; in-house design & IP ownership, outsourced manufacturing	Full-stack Electro-Optical/Infrared with proprietary subsystems	Owns 100% Electro-Optical/Infrared IP, modular + miniaturized systems	Sold to over 24 countries; strong in Asia, MENA, LATAM; validated in US, EU, Israel
Teledyne FLIR	Vertically integrated; designs and manufactures sensors/modules in-house at scale	High-volume thermal imaging modules	Thermal specialists, limited control stack	Global; strong in North America, Europe, NATO allies, and industrial-commercial sectors
Theon International	Vertically integrated; builds full night vision and thermal systems for NATO clients	Night vision and thermal optics for NATO	Tactical systems, NATO-oriented	Predominantly Europe and NATO countries; exports to over 50+ nations
Controp	Product-focused; designs Electro-Optical/Infrared gimbals in-house; manufacturing appears partially internal	Stabilized Electro-Optical/Infrared gimbals	Turnkey surveillance, motion-control expertise	Exports to 71 countries across Asia, Africa, Europe, and LATAM
Hensoldt	Vertically integrated; large-scale defense OEM with strong internal production and systems integration	Integrated Electro-Optical/Infrared in large platforms	Vertically integrated with NATO primes	Strong export presence across Europe, NATO, and Asia; key supplier to German & EU MoDs
Eprius	Venture-backed; vertically integrated design around HPM, manufacturing partly in-house and through U.S. defense primes	Leonidas HPM counter-UAS, scalable power modules, AI-driven power electronics	Non-kinetic directed-energy effect, optimized for drone swarm and rapid deployment	Primarily U.S. DoD (Army, Navy); early allied deployments at overseas bases; expansion to NATO and partner markets

Source: Frost & Sullivan

Tonbo Imaging competes with a cohort of established global Electro-Optical/Infrared companies, many of which follow traditional vertically integrated business models. Companies like Teledyne FLIR, Theon International, and Hensoldt design and manufacture systems in-house, supplying directly to NATO and government customers. In contrast, Tonbo Imaging adopts a horizontally integrated model, combining proprietary in-house design and IP ownership with outsourced manufacturing, an approach that enhances agility and capital efficiency. Founded in 2008, Tonbo Imaging is a recognized OEM providing a diverse suite of field-tested electro-optic products free from export restrictions under International Traffic in Arms Regulations ("ITAR"). ITAR is a U.S. export control framework governing the sale, transfer, and sharing of defence related technology, data, and services. Tonbo's full Electro-Optical/Infrared portfolio is entirely free from ITAR, enabling it to serve non-aligned and export sensitive markets more flexibly, as the company designs and develop their products within India, making us one of the few global OEMs capable of supplying cutting-edge technologies without geopolitical export limitations. Tonbo's products have been sold globally to customers in EU, US and Israel enabling adoption in India through a global first approach, underscoring their acceptance in some of the world's most advanced defence markets.

12.3 Innovation and Technology Comparison (Indian Peers)

Table 36: Innovation and Technology Comparison (Indian Peers)

Company	Unique Technologies	R&D Focus	Proprietary Solutions
Tonbo Imaging	Microscanning, AI-IR edge processing	EO edge vision, stabilization	Diffractive optics, fused vision
Astra Microwave	RF, Microwave filters	Radar subsystems	Custom microwave modules
Zen Technologies	Anti-drone, real-time sim	Combat simulation	Drone kill-systems, VR tech
Paras Defence	EO systems, gimbals	Defence optics & electronics	Optronics integration
Data Patterns	Radar and avionics integration	Embedded defence electronics	Radar processors, power modules
Bharat Electronics	Multi-domain defence electronics: radars, EW suites, missile seekers	Radars, electronic warfare, network-centric systems, select Electro-Optical/ Infrared devices	Long-range surveillance radars, combat management systems, integrated naval platforms
Tata Advanced Systems	Composite airframes, missile canisters; platform integration	Platform integration, composites, avionics bays, C4ISR, ISR integration	Integrated UAV/ airframe platforms; build-to-print modules for primes
VEM Technologies	IIR seekers, dual-mode seekers, IMUs/autopilots; propulsion & launchers	Missile guidance, seekers & strapdown nav; ATGM subsystems and test equipment	Indigenous seeker/IMU stacks, launcher electronics; Electro-Optical/Infrared terminal guidance kits

Source: Frost & Sullivan

12.4 Innovation and Technology Comparison (Global Peers)

Table 37: Innovation and Technology Comparison (Global Peers)

Company	Unique Technologies	R&D Focus	Proprietary Solutions
Tonbo Imaging	Microscanning, AI-IR edge processing	EO edge vision, stabilization	Diffractive optics, fused vision

Teledyne FLIR	High-volume thermal imaging cores & sensors	Thermal imaging, small UAS payloads, robotics	Compact Electro-Optical/Infrared modules, Black Hornet nano-UAS
Theon International	Customizable NV/TI optics, soldier-borne systems	Night vision, thermal fusion, optronics design	NATO-standard NVGs, thermal weapon sights
Controp	Stabilized Electro-Optical/Infrared gimbals, precision motion control	Long-range surveillance, border/coastal Electro-Optical/Infrared	Turnkey stabilized gimbal solutions
Hensoldt	Multi-sensor integration (radar + Electro-Optical/Infrared + EW)	Intelligence, Surveillance, and Reconnaissance (ISR), electronic warfare, situational awareness	Large-platform Electro-Optical/Infrared suites, optronics integration
Epirus	AI-driven semiconductor-based HPM power systems	High-power microwave directed energy	Leonidas C-UAS HPM system

Source: Frost & Sullivan

12.5 Product Portfolio Comparison (Indian Peers)

Table 38: Product Portfolio Comparison (Indian Peers)

Company	Comparable Product Lines	Typical Platforms/ Applications
Tonbo Imaging	Compact Electro-Optical/Infrared payloads, soldier-borne sights, AI-enabled targeting systems, low-SWaP gimbals	UAVs, UGVs, armored vehicles, soldier kits
Astra Microwave	Microwave subsystems, RF components, radar front-ends	Ground radar, satellite payloads
Zen Technologies	Drone simulators, C-UAS systems	Training, counter-drone defense
Paras Defence	Large Electro-Optical/Infrared gimbals, optics integration	Aircraft, ships
Data Patterns	Avionics, radar processor, electronic subsystem	Missiles, aircraft, EW systems
Bharat Electronics	Thermal sights, stabilized imagers, large-scale Intelligence Surveillance Reconnaissance (ISR)	Tanks, aircraft, naval platforms
Tata Advanced Systems	UAV airframes, Intelligence, Surveillance, and Reconnaissance (ISR) UAVs, platform Electro-Optical/Infrared integration, radomes/ missile canisters, composites	Aircraft, UAVs, ships, ground vehicles
VEM Technologies	IIR/dual-mode seekers, IMUs/autopilots, ATGM subsystems, launchers, test gear	Soldier/vehicle launchers, missiles, loiterers

Source: Frost & Sullivan

12.6 Product Portfolio Comparison (Global Peers)

Table 39: Product Portfolio Comparison (Global Peers)

Company	Comparable Product Lines	Typical Platforms/ Applications
Tonbo Imaging	Compact Electro-Optical/ Infrared payloads, soldier-borne sights, AI-enabled targeting systems, low-SWaP gimbals	UAVs, UGVs, armored vehicles, soldier kits
Teledyne FLIR	Thermal cores, large Electro-Optical/Infrared turrets, UAS imaging pods	UAVs, vehicles, soldier systems
Theon International	NV/TI optics, soldier-borne systems, fused night-vision devices	Infantry modernization programs, NATO SOF units

Controp	Stabilized Electro-Optical/Infrared gimbals, maritime Intelligence, Surveillance, and Reconnaissance (ISR) systems	Naval, border security
Hensoldt	Large-platform Electro-Optical/Infrared, radar/EO integration	Fighters, naval ships, ground Intelligence, Surveillance, and Reconnaissance (ISR)
Epirus	HPM-based counter-drone/electronic warfare systems	Ground-based C-UAS

Source: Frost & Sullivan

12.7 Financial Benchmarking FY23–Q1FY26 (India Peers)[1]

12.7.1 Revenue

Table 40: Revenue Benchmarking of Indian Peers, INR Million, FY23-Q1FY26

Company	**FY23**	**FY24**	**FY25**	**Q1FY26**	**CAGR (%)[2] (FY23-FY25)**
Tonbo Imaging	968.28	4,281.89	4,690.80	686.77	120.10%
Paras Defence and Space Technologies	2,224.26	2,534.98	3,646.61	931.90	28.04%
Data Patterns	4,534.50	5,198.00	7,083.50	993.30	24.99%
Astra Microwave Products	8,155.16	9,088.20	10,511.79	1,997.25	13.53%
Zen Technologies	2,188.46	4,398.52	9,736.42	1,582.19	110.93%
Bharat Electronics	176,462.00	202,682.40	237,687.50	44,397.40	16.06%
VEM Technologies	2,050.28	3,422.28	NA	NA	N/A
Tata Advanced Systems	34,691.40	47,925.20	51,231.30	NA	21.52%

Tonbo Imaging posted a revenue CAGR of 120.10% (FY23-25), positioning it as the fastest-growing defence technology company in India, with Zen Technologies at second positioning.

12.7.2 Gross Profit

Table 41: Gross Profit Benchmarking of Indian Peers, INR Million, FY23 – Q1FY26

Company	**FY23**	**FY24**	**FY25**	**Q1FY26**	**CAGR (%)[3] (FY23-FY25)**
Tonbo Imaging	380.22	2,082.60	2,644.69	340.03	163.74%
Paras Defence and Space Technologies	NA	NA	NA	NA	NA
Data Patterns	2,825.00	3,547.00	4,323.00	792.00	23.70%
Astra Microwave Products	2,970.00	3,630.00	4,740.00	930.00	26.33%
Zen Technologies	NA	NA	NA	NA	NA
Bharat Electronics	NA	NA	NA	NA	NA

VEM Technologies	NA	NA	NA	NA	NA
Tata Advanced Systems	NA	NA	NA	NA	NA

12.7.3 Gross Profit Margin (%)

Table 42: Gross Margin Benchmarking of Indian Peers, FY23 – Q1FY26

Company	FY23	FY24	FY25	Q1FY26
Tonbo Imaging	39.27%	48.64%	56.38%	49.51%
Paras Defence and Space Technologies	NA	NA	NA	NA
Data Patterns	62.30%	68.24%	61.03%	79.73%
Astra Microwave Products	36.42%	39.94%	45.09%	46.56%
Zen Technologies	NA	NA	NA	NA
Bharat Electronics	NA	NA	NA	NA
VEM Technologies	NA	NA	NA	NA
Tata Advanced Systems	NA	NA	NA	NA

12.7.4 EBITDA

Table 43: EBITDA Benchmarking of Indian Peers, INR Million, FY23 – Q1FY26

Company	FY23	FY24	FY25	Q1FY26	CAGR (%)[4] (FY23-FY25)
Tonbo Imaging	102.24	1,123.24	1,390.67	149.69	268.81%
Paras Defence and Space Technologies	567.41	510.55	972.03	NA	30.89%
Data Patterns	1,718.10	2,216.20	2,750.00	321.00	26.52%
Astra Microwave Products	1,480.00	1,920.00	2,690.19	410.00	34.82%
Zen Technologies	726.11	1,848.50	3,830.30	647.00	129.68%
Bharat Electronics	40,480.00	49,980.00	67,680.00	NA	29.30%
VEM Technologies	635.31	848.56	NA	NA	NA
Tata Advanced Systems	3,123.40	7,059.80	7,003.00	NA	49.74%

12.7.5 EBITDA Margin (%)

Table 44: EBITDA Margins Benchmarking of Indian Peers, FY23 – Q1FY26

Company	FY23	FY24	FY25	Q1FY26
Tonbo Imaging	10.56%	26.23%	29.65%	21.80%
Paras Defence and Space Technologies	25.51%	22.00%	28.00%	NA
Data Patterns	37.89%	42.64%	38.82%	32.00%
Astra Microwave Products	18.15%	21.13%	25.59%	20.50%
Zen Technologies	35.32%	42.03%	39.34%	40.90%

Bharat Electronics	23.00%	25.00%	29.00%	NA
VEM Technologies	30.99%	24.80%	NA	NA
Tata Advanced Systems	9.00%	14.73%	13.67%	NA

High EBITDA margin indicates profitability before depreciation, finance costs, and taxes. Tonbo Imaging improved significantly from 10.56% in FY23 to 29.65% in FY25.

12.7.6 PAT

Table 45: PAT Benchmarking of Indian Peers, INR Million, FY23 – Q1FY26

Company	**FY23**	**FY24**	**FY25**	**Q1FY26**	**CAGR (%)[5] (FY23-FY25)**
Tonbo Imaging	11.81	685.43	727.60	54.31	684.88%
Paras Defence and Space Technologies	359.40	300.38	614.92	142.70	30.80%
Data Patterns	1,240.00	1,816.90	2,218.10	255.00	33.75%
Astra Microwave Products	698.30	1,210.66	1,535.09	162.74	48.27%
Zen Technologies	499.68	1,295.04	2,993.35	530.75	144.76%
Bharat Electronics	29,862.40	39,852.40	53,226.80	9,690.50	33.51%
VEM Technologies	208.04	276.80	NA	NA	NA
Tata Advanced Systems	589.00	1,770.80	484.20	NA	-9.33%

12.7.7 PAT Margin (%)

Table 46: PAT Margins Benchmarking of Indian Peers, FY23 – Q1FY26

Company	**FY23**	**FY24**	**FY25**	**Q1FY26**
Tonbo Imaging	1.19%	15.87%	15.34%	7.68%
Paras Defence and Space Technologies	15.58%	11.47%	16.50%	14.93%
Data Patterns	27.34%	35.00%	31.30%	23.21%
Astra Microwave Products	8.60%	13.30%	14.60%	8.20%
Zen Technologies	22.10%	28.48%	29.00%	29.48%
Bharat Electronics	17.00%	20.00%	23.00%	21.05%
VEM Technologies	9.97%	7.99%	NA	NA
Tata Advanced Systems	1.64%	3.66%	0.94%	NA

Overall, Tonbo Imaging is the fastest-growing defence tech player in India in terms of Revenue, EBITDA and PAT margin growth (CAGR FY23-FY25) amongst the listed peers.

12.7.8 Return on Equity (ROE %)

Table 47: Return on Equity (RoE) Benchmarking of Indian Peers, FY23 – Q1FY26

Company	FY23	FY24	FY25	Q1FY26
Tonbo Imaging	4.02%	52.72%	20.20%	1.10%
Paras Defence and Space Technologies	9.09%	7.96%	11.70%	NA
Data Patterns	14.24%	15.00%	16.00%	NA
Astra Microwave Products	12.34%	13.93%	13.93%	NA
Zen Technologies	12.32%	33.47%	24.55%	NA
Bharat Electronics	23.52%	27.10%	29.56%	NA
VEM Technologies	9.00%	9.00%	NA	NA
Tata Advanced Systems	NA	NA	NA	NA

12.7.9 Return on Capital Employed (ROCE %)

Table 48: Return on Capital Employed (ROCE) Benchmarking of Indian Peers, FY23 – Q1FY26

Company	FY23	FY24	FY25	Q1FY26
Tonbo Imaging	14.33%	67.76%	27.36%	1.92%
Paras Defence and Space Technologies	12.24%	9.79%	13.28%	NA
Data Patterns	22.00%	16.00%	18.00%	NA
Astra Microwave Products	15.65%	15.85%	16.53%	NA
Zen Technologies	17.33%	40.56%	20.78%	NA
Bharat Electronics	33.15%	36.44%	39.22%	NA
VEM Technologies	12.00%	11.00%	NA	NA
Tata Advanced Systems	NA	NA	NA	NA

Notes:

1. Revenue from operations means the revenue from operations for the year/period as appears in the financial information.
2. Gross Profit for Tonbo Imaging = Revenue From Operation – COGS; COGS = Cost of Materials Consumed + Changes In Inventories of Finished Goods
3. Gross Profit for Data Patterns and Astra Microwave is as per their respective public company filings
4. Gross Profit % for Tonbo Imaging, Data Patterns and Astra Microwave= Gross Profit / Revenue from Operations
5. EBITDA for Tonbo Imaging = Profit / (Loss) before Exceptional and Extraordinary items and Tax + Finance Cost + Depreciaton and Amortisation – Other Income
6. EBITDA for Paras Defence, Data Patterns, Astra Microwave, Zen Technologies and Bharat Electronics is as per their respective public company filings
7. EBITDA % for Tonbo Imaging, Data Patterns (FY23-FY25), Astra Microwave (FY23-FY25) and Bharat Electronics = EBITDA / Revenue from operations
8. EBITDA % for Paras Defence, Data Patterns (Q1FY26), Astra Microwave (Q1FY26) and Zen Technologies is as per their respective public company filings
9. PAT for Paras Defence, Data Patterns, Astra Microwave, Zen Technologies and Bharat Electronics is as per their respective public company filings. PAT for Tonbo Imaging has been sourced from their restated financal statements.
10. PAT % for Tonbo Imaging, Data Patterns (Q1 FY26), Paras Defence, Zen Technologies and Bharat Electronics (Q1 FY26) = Profit After Tax / Total Income

11. PAT % for Data Patterns (FY23-FY25), Astra Microwave and Bharat Electronics (FY23-FY25) is as per their respective public company filings
12. ROCE % for Tonbo Imaging = Earning before interest and taxes / Capital Employed
13. ROCE % for Paras Defence, Data Patterns, Astra Microwave, Zen Technologies, Bharat Electronics and VEM Technologies is as per their respective public company filings
14. Earnings before interest and taxes = EBITDA – Depreciation and amortization
15. Capital Employed = Tangible Net Worth + Total Debt + Deferred Tax Liability
16. Tangible Net Worth = Total Net Worth – Other Intangible Assets
17. RoE% for Tonbo Imaging = Net Profits after taxes / Average Shareholder's Equity
18. ROE % for Paras Defence, Data Patterns, Astra Microwave, Zen Technologies, Bharat Electronics and VEM Technologies is as per their respective public company filings
19. ROE % and ROCE % of Astra Microwave and Bharat Electronics are on standalone basis
20. For Tonbo Imaging - Q1FY26 RoCE, RoE, Net Tangible Fixed Asset Turnover have not been annualized
21. For Tonbo Imaging - Q1FY26 Working Capital Days have been calculated basis 91 days
22. For VEM Technologies – Financials for Q1FY26 and FY25 are not publicly available
23. For Tata Advanced Systems - Financials for Q1FY26 are not publicly available
24. NA means not available.
25. For Tonbo Imaging - Q1FY26 RoCE, RoE, Net Tangible Fixed Asset Turnover have not been annualized
26. For Tonbo Imaging - Q1FY26 Working Capital Days have been calculated basis 91 days

Sources:

- Financials for Tonbo Imaging Pvt Ltd are taken basis of restated financial statements.
- Financials for Bharat Electronics Ltd. are taken from consolidated financial information as set out in its public company filings.
- Financials for Data Patterns Ltd are taken from standalone financial information as set out in its public company filings.
- Financials for Astra Microwave Ltd are taken from consolidated financial information as set out in its public company filings.
- Financials for Zen Technologies Ltd. are taken from consolidated financial information as set out in its public company filings.
- Financials for VEM Technologies Pvt Ltd are taken from standalone financial information as set out in its public company filings.
- Financials for Tata Advanced Systems Ltd are taken from consolidated financial information as set out in its public company filings.