





Defense News Conclave Stories of U.S. - India Defense Partnership

Critical & Emerging Technologies in the Defense Ecosystem

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President Biden and Prime Minister Modi affirm that technology will play the defining role in deepening the bilateral partnership, jointly stated during the State Visit of Indian Prime Minister to the U.S. on June 22, 2023. The announcement of U.S.-India initiative on Critical and Emerging Technology (iCET) in 2022, and its formal inauguration in January 2023 elevated and expanded the strategic technology partnership. It is hailed as a major milestone in U.S.-India relations.

The iCET aims to position the two countries as trusted technology partners by building technology value chains and supporting the co-development and co-production of dual-use items. It also aims to address regulatory restrictions, export controls and mobility barriers through a standing mechanism.

Enhancing long-term research and development cooperation, with a focus on identifying maritime security and Intelligence Surveillance Reconnaissance (ISR) operational use cases is significant for an open, free and prosperous Indo-Pacific and the larger Indian Ocean. Developing a new bilateral Defence Industrial Cooperation Roadmap between the U.S. and India to accelerate technological cooperation between both countries for the joint development and production of critical and emerging technologies in defence ecosystem with an initial focus on exploring projects related to jet engines, munition related technologies, and other systems is eminent. Additionally, the launch of U.S.-India Strategic Trade Dialogue to address export controls, explore ways of enhancing high technology commerce would facilitate transfer of technology between the two countries.

The military apparatus of the globe is witnessing significant transformations each day and is leveraging technology trends to strengthen capabilities. Emerging military technology warfares are changing the battlefield in five aspects – autonomy, connectivity, lethality, remotely controlled and sustainability.

CETs (Critical and Emerging Technologies) in defence ecosystem are a subset of advanced technologies that are potentially significant to national security and have become of utmost importance in the modern warfare, which includes land, air, space, electric, cyber and underwater warfare with enhanced lethality and ISTAR (Intelligence, Surveillance, Target Acquisition and Reconnaissance). CETs ensure that the force retains its combat edge, amid the world upgrading its technologies. In this regard, CETs are essential for countries such as the U.S. and India to develop a joint long-term national security and economic prosperity. This would facilitate goal for strong, prosperous and secure world.

Introduction

The precedence for identifying select goods as "critical" arose in the 1920s when dependence on foreign imports of certain materials was judged to be of vulnerability for the U.S. military.

Technology has always been a primary agent to decide, redefine or reshape the war parameters with some distinctive, innovative outputs. That is also known as state-of-the-art technologies which are crucial in the times of a shift from the human-centric warfare approach to hybrid warfare.

CETs are current and emerging technologies with the capacity to significantly enhance, or even pose risk to national interests (economic prosperity, social cohesion and/or national security). These are technologies, which are selected for their potential to aid in achieving specific goals. CETs are essential for countries as they transform the modern platforms with greater lethality, longer and undetected ranges and pin-point accuracy.

Within this larger subset, the terminology 'Emerging Technology' refers to the development of either a new technology or continuing advancement of existing technologies, which may be widely available in near future. Further, CETs also include dual-use technologies, that is, technologies, which have potential application in both civil-commercial and defence realms. Dual-use technologies that are likely to have defence-related applications in the future would be 1) Robotics and Artificial Intelligence 2) Fusion and Space Technology 3) Missile technology and Hypersonics 4) Nano technology and bio-technical weapons 5) IT and cyber warfare technology 6) Unmanned and piloted weapons 7) bio-fuels for vehicles 8) material technology such as stealth, thorium and

weapons and vehicles made of the same among others would shape the conflicts of the future.

In the uncertain geopolitical scenario, most countries face geographical and strategic threats emanating from various fronts, borders and with multi-domain warfare becoming an essential tool to win wars, the CETs have become essential in order to modernise the defence ecosystem. Fleeting encounters with high-technology weapons and munitions will become common place and this can already be witnessed in recent episodes of border issues globally. In the wars to come, and with further advancement, ownership and procurement of technologies such as the 5G/6G in communication, Artificial Intelligence (AI), Machine Learning (ML), Big Data analytics, Internet of Things (IoT), Augmented Reality (AR), Virtual Reality (VR), Nano technology, Quantum technology, and semiconductors all would be leading to have revolutionary changes in the capabilities of the weapon platforms, data processing and military hardware.

The experts in these fields are already aiming to induct disruptive platforms with these highly intensive tech bases and producing modern warfare like swarm drones, loiter munitions, armed Unmanned Aerial Vehicles (UAV), Remotely Piloted Aircraft Systems (RPAs), robots and autonomous weapon platforms to name a few in the military arsenal.

The usage of CETs in military adventures has been witnessed in recent decades, which supplements the changing phase of the future war, which is becoming more unconventional and hybrid. The definition of CETs may differ from source to source and country to country as it lacks the foundational elements and common consensus about what constitutes as critical and what as emerging technology but a broader consensus is drawn in this paper. The recent years have shown some glimpses of how CETs would prove to be a defining moment in the wars to come.

Nagorno-Karabakh Conflict

First notable instance of global conflict where unmanned arms were used in another country. Azerbaijan military used these <u>'Harop' loitering munitions</u> in Armenia during the Nagorno-Karabakh conflict, 2020.



Tactical Nuclear warheads in Russia-Ukraine War

The recent war between Russia and Ukraine has shown that the tactical weapons and latest art-of-the-technique weapons have burst onto the international stage. There has been use of tactical weapons which are synonymous to battlefield or nonstrategic nuclear weapons, designed to counter conventional forces like the large formations of infantry and armor. There has been usage of the tactical bomber – Iskander-M (short-range missile systems) by the Russian side, American made HIMARS and UAVs being used by the Ukrainian side for tactical gains.

Definition of CETs in the U.S. and India

According to Defence Research Development Organisation (DRDO), the Research & Development (R&D) arm of the Ministry of Defence, India, identifies CETs by means of two basic tenets –

- (i) The Global Technology Developments
- (ii) User's Long Term Plans & Missions.

In India, the DRDO's mission is to design and develop state-of-art defence systems and technologies and to provide technological solutions to the services while developing quality infrastructure. For example, DRDO is developing electronic warfare systems, which will be vital for all three wings of the armed forces. It seeks to also develop in the near future, network-centric warfare components, hypersonic vehicle technology and other advanced materials. The weapons that could win wars would be ranging from a small computer virus to hypersonic missiles.

The U.S. in its 'National Strategy for Critical and Emerging Technologies', 2020 defines CETs as those technologies that have been identified and assessed by the National Security Council (NSC) to be critical, or to potentially become critical, to the United States' national security advantage, including military, intelligence, and economic advantages. The government has prepared a list and demarcates the technologies as mentioned below.

ANNEX

UNITED STATES GOVERNMENT CRITICAL AND EMERGING TECHNOLOGIES LIST

The Critical and Emerging Technologies (C&ET) list reflects the 20 technology areas that United States Government Departments and Agencies identified to the National Security Council staff as priorities for their missions. The list will be reviewed and updated annually via the interagency process coordinated by the National Security Council staff. The technology areas are arranged alphabetically.

Advanced Computing	
Advanced Conventional Weapons Technologies	
Advanced Engineering Materials	
Advanced Manufacturing	
Advanced Sensing	
Aero-Engine Technologies	
Agricultural Technologies	
Artificial Intelligence	
Autonomous Systems	
Biotechnologies	
Chemical, Biological, Radiological, and Nuclear (CBRN) Mitigation Technologies	

Communication and Networking Technologies Data Science and Storage Distributed Ledger Technologies Energy Technologies Human-Machine Interfaces Medical and Public Health Technologies Quantum Information Science Semiconductors and Microelectronics Space Technologies

The new generation of AI and the Warfare:

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Artificial intelligence (AI) has become one of the most emerging technologies and serves both civilian and military purposes. With the advancement of technology, AI becomes an important tool in defence forces. Various purposes have been served by AI in enhancing the defense architecture. Functions like intelligence, surveillance and reconnaissance, logistical assistance, training assistance, command and controlling, automated weapons, cyber-attacks and cyber security, minesweeping, combat simulation with virtual reality etc., can be performed more efficiently with the help of AI.

Coastal Surveillance Network



A Coastal Surveillance Network (CSN) is a series of static sensors comprised of radars, Automatic Identification System (AIS), and Day/Night sensors on the 46 surveillance locations along the coastline of India. It was launched in 2008, after the Mumbai terrorist attacks. In the second phase of this project, 38 more radar arrays and eight mobile surveillance devices have been installed, in addition to the Vessel Traffic Management System (VTMS), to ensure the free-gap surveillance of the whole coastline. It can recognise sub-20-meter boats such as fishing boats, dinghies, and local boats in areas with a lot of marine debris, in all-weather circumstances. The radar has the ability to run continuously. Additionally, it includes cuttingedge monitoring algorithms to follow over 1500 sea surface targets. It has networking capabilities to operate both locally and remotely.

Basics of Tomorrow: Quantum Technology

Apart from decrypting classified information, quantum technology is expected to revolutionise military capabilities such as cyber security, AI, communications, intelligence, surveillance, target acquisition, reconnaissance, chemical and biological warfare simulation and detection, electronic warfare, underwater warfare, space warfare, new material design and man-machine. It is a dual-use technology and it introduces new capabilities, improving effectiveness and increasing precision, thus leading to 'Quantum Warfare', wherein new military strategies, policies, doctrines and ethics need to be established.



The technologies arising out of the second and the third quantum revolution would form the basis of the wars to come. This would not only mean bringing new weapons and hard wares but also advancing the existing military technologies such as nuclear power, semiconductors, lasers, and imaging devices, which were a result of the first quantum revolution. Quantum technologies are considered both critical and emerging as they have the potential to change the outcomes and functioning of warfare. As a step in the future, there can be a joint or standalone national quantum ecosystem strategy/plan as quantum technology would impact all the domains of modern warfare.

In its Union Budget for 2020-21, India announced a National Mission on Quantum Technologies & Applications (NM-QTA) with a total budget outlay of Rs 8000 crore for a period of five years to be implemented by the Department of Science & Technology (DST). The range of quantum technologies is expected to catalyse disruptions that will change entire paradigm of computation, communication and encryption. As an outcome of the budgetary outlay, the Ministry of Electronics and Information Technology (MeitY) launched the 'Quantum Computer Simulator (QSim) Toolkit' to provide a quantum development ecosystem.

Future wars will be synonymous with technology wars or unmanned wars, critical to economic growth and overall security. Some of the technologies that are likely to have defencerelated applications or dual-use technologies crucial in warfare have been mentioned in this paper. For better understanding, this paper would cover CETs in three domains, namely:

- 1. Maritime CETs
- 2. Land/Terrestrial CETs
- 3. Airborne CETs

1. Maritime CETs

Chief of Naval Staff Admiral <u>R Hari Kumar</u> "The battlefield will transcend physical boundaries. It will be fought over the seas, on land, in the air, in the information domain, in the digital world, and even in our minds"

India is a maritime nation with a coastline of 7,516 km with 1,197 offshore islands and Exclusive Economic Zone (EEZ) of 2.01 million sq. km that is highly rich in resources. The nation's maritime interests encompass the maintenance of the territorial integrity of India against all types of seaward challenges as well as the protection of the maritime trade and secure environment. As the security challenges are only bound to increase, India requires a strong and modern Navy to protect its varied maritime interests and shoulder additional responsibilities, particularly in the current geo-political and security situation that prevails in the Indian Ocean Region.

The CETs in the maritime include robotics and autonomous unmanned systems, nuclear powered submarines, new undersea systems, AI and nanotechnology induced technologies, electronic warfare, nuclear powered destroyers and aircraft carriers having Electromagnetic Aircraft Launch Systems (EMALS), currently developed by the General Atomics for the U.S. Navy. The networking technologies for sea and undersea applications along with other software technologies would buttress maritime geopolitics. These technologies remain highly important as they have the potential to manage high-volume data, with real-time and quick assessment of the situation, and quicker and automatic commands, which substitute human reaction time.

The Indian Naval force looks to acquire state-of-the-art technologies and this is reflected

in the <u>Navy's Maritime Capability Perspective</u> <u>Plan</u> (MCPP). To embrace modern cutting-edge marine defence technologies and boost the innovation and indigenisation process, the Indian Naval Indigenisation Plan<u>(INIP) 2015-2030</u> has been formulated.

Hybrid and technological warfare are demanding a revolution in military technologies demanding greater impetus given to the innovation and development of disruptive technologies.

Towards this end, the Naval Innovation and Indigenisation Organisation (NIIO) is currently in consultation with around 120 start-ups for induction of niche technology in unmanned and autonomous systems, secure communication, smart weapons, surveillance and imaging.

A <u>Technology Development Acceleration</u> <u>Cell</u> (TDAC) has been created under Naval Innovation and Indigenisation Organisation (NIIO) to focus on innovation in CETs. This cell engages with the academia and the industry in addition to channeling in-house naval innovations. Deep tech startups are also being recognised as 'Innovation Industry Partners' to focus on innovating military applications from the emerging disruptive technology, which is being pursued by TDAC.

As per the given mandate of TDAC, it has all the potential to become an indigenous version of the U.S.-based 'DARPA'. In the post-Cold War era, DARPA has played a key role in developing the information technology behind the so-called revolution in military affairs.

Further, as the Indian Ocean and Indo-Pacific remains highly important for the times to come, and staying in-sync with India's vision of becoming a net security provider in this free, open and prosperous region, the Indian defence forces are developing CETs, which will not be important just for the Indian sub-continent but for larger Indo-Pacific region.

Maritime areas are the growth underbelly of the Indo-Pacific region. The U.S. along with various other countries have underlined its vision and strategy for this region. In the Biden-Harris National Security Strategy, 2022, the Indo-Pacific region has been given a separate chapter. As the former Indian Naval Admiral Sunil Lanba chief says *"The Indo-Pacific is the new arena of geo-political, geo-economic and technical competition and contestation"*. To safeguard this region, it would require state-of-the-art technologies co-produced and co-manufactured by like-minded nations and signing key partnership projects to develop maritime CETs.

For India's geostrategic gains and larger Indo-Pacific and surrounding waters, it needs to build and operate niche technology weapons. Some of potential collaborations with the U.S. have been highlighted below.

India has emerged as a hub for maintenance and repair for forward deployed U.S. Navy assets. The signing of Master Ship Repair Agreements (MSRA) will allow the U.S. Navy to expedite the contracting process for midvoyage and emergent repair.

With the development of new technology submarines by the adversaries, the demand of anti-submarine warfare is rising. Low detector sonars and defensive submarines fitted with ISR for intelligence gathering, special operations, deep strike need to be developed. For high-speed and undetected patrolling purposes, midget or small-size submarines would be advantageous. This could be used in special operations by the Indian Coast Guards (ICG), the Indian Navy or the Marine Commandos (MARCOS). **Project 75 Alpha** for Nuclear Powered Attack Submarine (SSN) – The Indian Government had approved the construction of six such submarines in February 2015. These submarines will be designed by the Navy's inhouse Directorate of Naval Design and indigenously built in the shipbuilding centre by 2032. Similarly, under the AUKUS (Australia, United Kingdom and the United States) strategic framework, Australia is set to receive Virginia-class submarines beginning in 2032 and co-develop a new AUKUS-class submarines in decades to come.



Future warfare will be dictated by technological superiority and disruptive technologies would govern the geopolitics of the Indo-Pacific region. Therefore, there would be high reliance on technology and information flow. As the India-U.S. partnership is a strategic maritime alliance and the future wars will be essentially technology-driven, there is a need for a greater Transfer of Technology (ToT) and joint production.

The key to India's emergence as a global power would depend on a high degree of jointness, interoperability and ToT. The Quadrilateral group comprising of Australia, India, Japan and the U.S., would be required to develop advanced naval capabilities like signal processing, data fusion capabilities and jointmodern weapons to enhance the security of the region.



Boeing Company's P8I: The Indian Navy's frontline multi-mission aircraft Designed for long-range, anti-submarine warfare (ASW), anti-surface warfare (ASuW), and intelligence, surveillance and reconnaissance (ISR) missions, the P-8 delivers highest levels of quality, reliability, and operability. Components such as radar fingerprinting system, IFF (I/T) and datalink, mobile satcom system, speech secrecy system and other critical components are made in India by supplier partners including MSMEs located in the nation. Along with this, Boeing also provides training to Indian Navy flight crews, spare parts, ground support equipment, field-service representative support and critical data handling.

The Indian Navy is also building a Naval Communications Network (NCN) that involves 2,900 km of optical fibre cable. Sterlite Tech will be responsible for the design, construction and maintenance of the digital communications network that will be provided to the Indian Navy as part of the Rs 3,500 crore system integration projects. This will put the Indian Navy on par with the most advanced naval forces in the world. Once it is finished, it will link several Indian naval facilities as well as islands that are managed by India. A high-capacity Internet Protocol–Multi Protocol Label Switching (IP– MPLS) network is going to be built as part of this project.

There should be cooperation among likeminded countries and especially the Quad-AUKUS member states in developing capabilities and best practices including advanced undersea warfare, water space management, unmanned deep water vehicles and enhanced Maritime Domain Awareness (MDA). These would secure the anti-submarine warfare (ASW) readiness and there should be joint deployment of surveillance towed array sensor systems in the Bay of Bengal and the Indian Ocean.

2. Land/Terrestrial CETs

Former Chief of Defence Staff General Bipin Rawat said, "The 21st Century has seen a paradigm shift in warfare through rapidly evolving, dual-use, state-of-the-art technologies. With advancements in the field of niche technologies, warfare is transiting to the Noncontact domain, wherein technological ascendancy will be a critical factor in defining outcomes".

As India faces a two-front war dilemma and two of its neighbours are nuclear weapon states with unstable histories of wars, it needs to constantly aim for technological superiority in the territorial battlefields. The total shared border with Pakistan and China is more than 6,800 km and in order to safeguard the same, there needs to be constant production, upgradation and innovation in land-based CET weapons.

Emerging technologies in land warfare are spawning entirely new concepts of war fighting. Some of the artefacts, which the Indian Army would be wanting to procure and produce would be armoured fighting vehicles systems, hypersonic missiles, ammunitions, body-armours & armour protections, sensors, simulators, specialised vehicles, night vision sights among other next-generation technology gears and weapons which would see them winning battles.

India is in the pursuit of producing highlyspecialised weapons and state-of-the-art technology arms and ammunitions such as Para Droppable Gun Tower, a heavy counter improvised explosive device (IED) robotic system and High-Powered Electromagnetic Weapon System (HMVS), which would be effective against avionics and radars of aircrafts, and enemy drones. Deploying robots in the battlefield along with reducing the human casualties and production of heavy counter improvised explosives device robotic systems, for carrying out surveillance and explosive ordnance disposal vehicles, automobiles and larger open areas are need of the hour.

Integrated Electronic Warfare (EW) systems would evolve the defence ecosystem by detecting, classifying, monitoring communication with pin-point accuracy in the difficult terrains such as northern and western desert. The use of next generation mine system, para droppable gun tower, would be crucial for carrying out surveillance and explosive ordnance disposal inside vehicles and in open or disputed border skirmishes.

Technology has assumed a significant role in warfare and is today a major battle winning

factor. Technology driven war machines on land will be a decisive arbiter in future wars.

The Government of India, after the launch of the "Make in India, Make for the World" initiative has placed the defence sector at the core of its flagship initiative and look towards producing cutting-edge technologies in this era. This would be crucial in carrying out multiprotocol target detection, classification, identification, locating and jamming the adversaries. For information gathering, Communication Intelligence (COMINT) capability including electronic support measures, electronic counter measures and Electronic Intelligence (ELINT) would be developed. For incoming aerial threats, passive surveillance system generating 3D air situation pictures and providing multi-channel passive accurate and dynamic tracking of airborne targets would be game changer.

These technologies have the potential to provide India with an opportunity to leapfrog into the next generation of technologies and reducing soldiers' physical and cognitive workload and ensuring reduction in casualties, and protecting forces. The integration of Robotics & Autonomous Systems (RAS) technologies allows militaries to achieve these objectives and control terrain, secure populations, and consolidate gains against various odds in hybrid wars. Additionally, these would also facilitate landmine clearances, search rescue operations, explosive ordnance disposal and logistics support.

The Indian Army's Make in India and innovation drive is spearheaded by <u>Army Design</u> <u>Bureau</u> (ADB) on the lines of the U.S.'s DARPA. The role of ADB is to undertake technology scans, identify technologies for acquisition and development, facilitate R&D efforts with industry, academia, DRDO & DPSUs, provide inputs and enable them to understand user requirements while initiating cases of design and development with the industry, all with the aim of promoting indigenisation. The ADB was created to provide an institutionalised interface towards building synergy between start-ups, incubators, R&D organisations, academia, industry and the Indian Army to address unique problems faced by our front-line forces.

DRDO & DARPA: New Age Collaboration for Co-developing CETs



Defense Advanced Research Projects Agency (DARPA, The Defense Advanced Research Projects Agency is a research and development agency of the United States Department of Defense responsible for the development of emerging technologies for use by the military)

DARPA created in 1958 to facilitate research in technology with potential military applications. Few of DARPAs Innovations in CETs have been F-22 fighters and B-2 bombers, battlefield sensors, blue-green lasers, non-acoustic forms of submarine detection and nanotechnology among others.

In the current wavering geopolitical scenario, the American leadership in CETs also faces growing challenges from strategic competitors, who recognise the benefits and organise massive human and capital resources on a national scale to tackle the lead in areas with long-term consequences. Similarly, the U.S. has remained as the champion of technology, especially since the 1990s and in order to remain on the leader board of disruptive technologies, the U.S. needs new strategic alliances and cooperation. Under the initiative of iCET the U.S. based agencies such as DARPA and Defence Innovation Unit (DIU) can work with R&D Co-operations based in Indian cities of Hyderabad and Bangalore and with DRDO and HAL (Hindustan Aeronautics Limited) like organisations, by setting up overseas offices, and embarking on coinvestment of funds with Indian counterparts to solve joint challenges by harnessing human resources, latest and niche technologies. Among many advantages India has, cheap skilled labour, would develop and manufacture new technology weapons and arms at lower cost. This would further add onto the revenue of the corporates.

A joint-venture or partnership between DRDO and DARPA would assist the American leadership, which faces growing challenges from strategic competitors, also it would harness the benefits and organise massive human capital resources on a long-term consequences. Potential Collaboration between Industries could be looked at. Above; a U.S. based aerospace and defence company manufactures advanced body suite for the armed forces. In India, the MoD has signed contracts with BEL (Bharat Electronics) <u>for advanced electronic</u> <u>warfare (EW) suite</u> manufactured by DRDO for fighter. aircraft pilots of the Indian Air Force.





Similarly, in case of light battle tanks, both India and the U.S. are looking to acquire and update their military capabilities and both may jointly develop the Iron Pentagon: with the given electronic and electrical features and a number of sensors (tethered drones, mini radars included), the future tank is likely to be fast moving, allterrain armoured vehicle capable of swift manoeuvres with precision fire. By this model of iron pentagon or a similar initiative, major lacuna would be checked by the major defence partners. Futuristic Infantry Combat Vehicles (FICVs) with night vision, fighting and ISR capabilities would be added advantage. These light battle tanks with latest state-of-the-art technologies would be highly useful in highaltitude areas, desert and dunes, marginal and marshy terrains and island territories as well.

Significant military benefits can accrue for India by investing in emerging technologies and provide an impetus to its aspiration of being a major player in a multipolar world order. However, the U.S. could help address constraining factors such as India's lack of quality research grants and its underdeveloped research and development (R&D) infrastructure to derive maximum benefit resulting from development of emerging technologies.

The CETs in this domain present both challenges and opportunities for India and the U.S. However, agency collaborations such as DRDO and DARPA, Government-to-industry and industry-to-industry collaborations can overcome challenges by sustaining their reform momentum and seize opportunities by making it easier for scientists to innovate and for companies to manufacture.

Joint Venture for Strategic Partnership

General Atomics' MQ-9Bs HALE UAVs will be assembled in India, this will enhance the ISR capabilities of India's armed forces across domains. Furthermore, GA will establish a Comprehensive Global MRO facility in India



3. Airborne CETs

India's Chief of the Air Staff, <u>Vivek</u> Ram Chaudhari, "The future warfare is likely to be hybrid in nature wherein weapons such as economic strangulation, information blackout, computer virus and hypersonic missiles would be used"

In the future, the warfare is likely to be hybrid in nature and the spectrum will be spread across all domains from conventional to subconventional, kinetic to non-kinetic and lethal weapons. Air power is critical in deciding the outcomes of wars. The importance of airborne warfare will only grow in future conflicts. There is a need to develop capabilities across the full spectrum of conflict and focus on airborne CETs.

Similarly, the doctrines, equipment, training and tactics have to be flexible and adaptable to these new technological changes.



<u>AUKUS</u>, the Indo-Pacific alliance of Australia, United Kingdom and United States have announced they will work together and develop hypersonic missiles and electronic warfare capabilities, and deepen information sharing network. The Pentagon's 2023 budget request already includes USD 47 billion for R&D of hypersonic weapons, which would include battery, sea-based missile and airbased cruise missile

To protect the nation from aerial threats, reliance on UAVs, RPAs, Aero-pods, 5th generation and twin-jet fighter planes, hypersonic aerial weapons and their integration with existing ground-based, maritime, and airborne systems for multi-layer protection against autonomous threats would be the first layer of secured protection. The light weight pods enable the destruction of critical electronic components, disabling drones, which have grown multi-folds in the recent conflicts.

Reliance on Virtual Augmented Mixed Reality for Aircraft Maintenance (VAMRAM) for terrain shaping obstacle, and counter-UAS, rocket, artillery and mortar (CURAM) system for the protection of the air bases, strips and layers would be given utmost priority. Along with Naval shipborne Unmanned Aerial System (Shipborne UAV) India is in pursuit of developing light combat multi-role helicopters, Twin Engine Deck Based Fighter (TEDBF), a carrier borne multi-role fighter, anti-radiation missiles, deck based multi role helicopters, Mach 5 speed hypersonic and supersonic aircrafts. These would be designed to serve multiple role of air force missions for ISR purposes and defence purposes.

As there is a renewed impetus on R&D and innovation, Indian startups should combine with U.S.-based startups develop directed energy weapon systems, which enables counterelectronics effects for a range of use cases. These pods integrate with existing ground-based, maritime, and airborne systems for multi-layer protection against autonomous threats. The light weight pods enable the destruction of critical electronic components, disabling drones.



TLMAL, a joint venture between Tata Advanced Systems Limited (TASL) and Lockheed Martin Aeronautics produced C-130J Super Hercules empennage from its manufacturing facility located in Hyderabad. These are essential for search and rescue, peacekeeping, combat delivery, maritime patrol, special operations, aerial refuelling, medevac and humanitarian response missions globally.

These kind of collaborations between the two nations at state-to-state level and also at privateto-private sector level could also help the situation in the Indian Ocean Region, national and international air-spaces. In this direction, India and the U.S. have signed a landmark signing of an MoU between General Electric and Hindustan Aeronautics Limited for the manufacture of GE F-414 jet engines in India, for the HAL Light Combat Aircraft Mk2.



In June, 2023 India has joined the Mineral Security Partnership (MSP), led by the U.S. The MSP is the partnership project on critical minerals between 14 countries including the U.S. and India. The joint statement of the two countries states that "to collaborate in order to guarantee a sufficient supply of the crucial important minerals in each of our markets" and "to expedite bilateral cooperation in order to establish robust supply chains for essential commodities."

Way Forward

As the world leader in C&ET, the United States contributes to and benefits from the technology ecosystems of its allies and partners, maintaining United States advantage and upholding a secure, free, and open international order based on democratic values.

As the technology leaders, the U.S. armed forces and mechanisms could help India achieve

the target of USD 25 billion of defence production and exports of USD 5 billion by 2025. Over the next few years the military trade between the two countries is expected to jointly dwell into R&D and co-produce and comanufacture in India under *Atmanirbhar Bharat* and *Make in India* initiatives. It would help both the nations to leapfrog in critical technologies and focus on major areas of cooperations.

Emerging technologies are said to have the potential to change "the rules of the game" whether that "game" is the balance of military power between security actors or the balance of competitive advantage in a market between incumbent companies and new entrants. With greater competition comes greater responsibility to promise quality and security. The way forward would also be marred with challenges, specially relating to the enthusiasm for adopting these emerging technologies, regulations and frameworks around them.

With ever increasing dependence on cyberspace and the internet, aspects of egovernance, public utility services and security there needs to be a robust framework to keep the misuse under check. The emergence of C&ETs has created new vulnerabilities for the Armed forces globally. Its exploitation to disrupt and deny its use by the adversary can now create leverages to achieve strategic goals.

The two democratic nation of India and U.S. can formulate frameworks or guidelines for

smooth flow of future deals. Both nations can contribute to a future where all military C&ET activities are conducted in accordance with the international rules-based global order, without disrupting, and preferably contributing to, the sustainable use of environment for the benefit of present and future generations of all humanity.

As we move forward both the nations need to be parties of groupings, which secure safe military usage in the outer space, land, oceans and develop polylateral groupings to safeguard technology transfer and ensure that the technologies are not misused or goes into the wrong hands.

The agenda of the frameworks protecting and safeguarding C&ETs is to contribute to a future where all ocean, space and land activities are conducted in accordance with the international rules-based global order, without disrupting, and preferably contributing to, the sustainable use of open waters, underground soil and outer space for the benefit of present and future generations of all humanity.

Lastly, adding weight to the need of the C&ET, India's Defence Minister mentioned that, "India and the U.S. have decided to advance cooperation in emerging technologies in the fields of communication, AI, quantum science, semi-conductors and bio-technology urging private industry of both nations to undertake joint development and production of defence equipment".

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