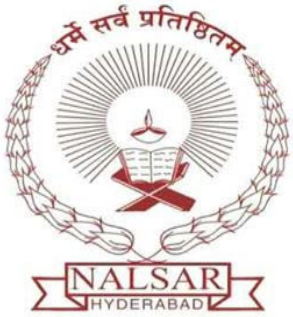

Centre for Aerospace & Defence Laws (CADL)
Directorate of Distance Education
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Course Material

M.A. (SECURITY AND DEFENCE LAWS)

1.1.3. Defence Technology and Defence Laws

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MODULE-I

Defence Technologies and Defence Applications

MODULE-I: DEFENCE TECHNOLOGIES AND DEFENCE APPLICATIONS

EQUIPMENT AND TECHNOLOGY REQUIREMENTS

The nation relies on the technological superiority of its armed forces. It is our endeavor to ensure that Indian Armed Forces always have the latest technology in our war fighting systems which propel us towards achieving a technological edge over our adversaries. To do this, we must understand the needs of defence forces. Fundamental to understanding those needs is an understanding of the strategic environment, existing now as also in the future, in which our armed forces operate/will operate.

Technological superiority is increasingly going to be the decisive factor in future battles. Warfare has already undergone rapid changes with the impact of new and emerging technologies of the past two decades, especially in the fields of electronics, miniaturization, materials and computing. This has had a profound impact on the development of more versatile systems across a wide spectrum of applications, ranging from communications to sensors and guided weapons. Computing technology has, in addition, made an entry into systems across every warfare capability thus adding a new dimension to modern war fighting. Adoption of the latest technology in developing new warfare systems would propel us towards our goal of achieving a technological edge over the adversary. This in turn would permit us to prevail decisively across the entire spectrum of conflict, even with reduced force levels, whilst ensuring that our forces suffer minimal casualties. The easy accessibility of modern weapons and systems employing the latest technologies is also a factor to be considered. This reality predicates that we be well equipped to handle threats arising from such proliferation in the most cost-effective and optimum manner.

To provide for national security in the 21st century, the Indian military must be able to dominate the full range of military operations, from humanitarian assistance to conventional warfare. This strategy requires the Department of Defence to help shape India's security environment in ways favourable to our national interests, respond to the full spectrum of crisis, and prepare now to meet the challenges of an uncertain future. Key to achieving this full spectrum dominance will be the ability of defence forces to acquire information superiority and the technologies that enable it. Our combat forces have to be lighter, more mobile, and more lethal. Technologies that enable this will also be a key. Now is the time to focus defence investments on the research and technology development needed to meet new and undefined threats. Technological superiority has to become the principal characteristic of our military advantage. Three important concerns will influence our choices for technology investments: leveraging the technology explosion, enabling the Information based Revolution in Military Affairs (RMA) and asymmetric threats.

Increasingly many defence needs can be met by leveraging the commercial technology explosion and utilising commercial products such as computers, software, electronics, and communications. As military capability moves toward information based warfare and as the

information age continues to experience a technology explosion in the civilian economy, there will be an abundance of opportunities to leverage commercial technology and products for military use. We should monitor commercial technology and product developments and adopt or leverage them for enhancing military capability. The defence forces, defence planners, scientists, and engineers should be brought together to explore ways to take advantage of the opportunities offered by rapid commercial technology advancements.

Our vision for the 21st century should be the war fighter who is fast, lean, mobile and prepared for battle with total battle space situation awareness and information assurance. Our military strategy should be based on information superiority and real-time intelligence from "sensor to shooter". The information age has given rise to a new information-based RMA galvanized by advances in information technologies and information processing capabilities hitherto unknown. Our nation maintains a significant advantage in the development of information based technologies. To succeed across the full spectrum of operations, we should develop innovative new concepts for conducting operations, test them through demonstrations and rigorous experimentation and rapidly transition the enabling technologies into revolutionary war-winning capabilities.

Asymmetric Threats

Our ability to achieve full spectrum dominance is likely to be challenged by the global spread of advanced technology which is transforming the military threats faced by our nation. In order to carry out our defence strategy, the Indian military must be prepared to conduct multiple and concurrent contingency operations both within the country and out of area. It must be able to do so in any environment, including one in which an adversary use asymmetric means such as information operations, ballistic missiles and terrorism or against an NBC backdrop. Our combat forces must be accordingly organised, trained, equipped and managed with multiple missions in mind. We must be conscious of these threats as we adopt or foster technology breakthroughs that will lead to new capabilities to cope with such an environment.

The development of technology to meet our future joint warfighting needs should aim at a broad-based programme spanning all defence-related sciences. Our strategy should thus be to ensure that we are able to develop and transform superior technology into affordable and decisive military capability. The five essential aspects to be kept in mind during development are:

(a) Affordability. Technology projects must focus on increasing the effectiveness of a capability whilst decreasing cost, increasing operational life and incremental improvements through planned upgrades.
(b) Timeliness/Accelerated Transition. The emphasis should be to ensure that the time taken for the transition of technology to usable capability is minimised.

(c) Dual Use. The development of technology that is amenable to being applied to both military, as also commercial use would not only contribute to building a common industrial base, thus enlarging the utility and consequently the cost of such technology, but lead to cost effectiveness due to economies of scale.

(d) Technology Base. The capability to undertake basic and applied research across a wide-ranging canvas is essential to generate applications and technologies of tomorrow. The development of a strong technology base is critical to focus such research towards throwing up options for the long-term, focused towards meeting the needs of the future warfighter.

(e) Modular Design. Considering the rapid rate of obsolescence of technology, the life of systems has reduced considerably. The life of warfighting platforms is, however, much longer and thus there is a mismatch requiring at least one major upgrade of weapons and systems during a platform's life. This aspect needs to be factored in at the design stage itself so that systems produced firstly have growth potential and secondly are modular in design so that upgrades/replacements can be undertaken without the need for major structural changes on the platform.

New military capability and operational concepts emerge from many different sources. The way to address future needs is to invest in broad areas of research that have high potential of yielding revolutionary advances as well as pursuing solutions to known operational problems. An investment in basic research pays dividends in many ways.

Basic research is a long-term investment with emphasis on opportunities for military application far in the future and contributes to our national academic and scientific knowledge base. Investment in basic research should be sustained because of proven, significant, long-term benefits to the military, which in turn enhances our national economic security. Basic research provides the foundation for technological superiority. Our nation's defence advantage should be founded on a wide scope of scientific and engineering knowledge. The Department must continue to invest broadly in defence-relevant scientific fields because it is not possib le to predict precisely in which areas the expected breakthroughs will occur.

The capability objectives required to enable the military to meet the challenges of the future battlefield have been identified and the likely technologies we would need to develop to achieve such capabilities have also 'been drawn out. These capabilities are:

(a) Information Superiority. Information Superiority (IS) encompasses the capabilities of Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) and Command, Control, Communications and Computers (C4) to acquire and assimilate information needed to dominate and neutralise the adversary and effectively employ own forces. This will require IS to include the capability for near real-time awareness of the locations and activities of both own and enemy forces throughout the battlespace. It also includes a seamless, robust C4 network connecting all own forces to provide a common

picture of the battlespace. The capability of information warfare is also needed to affect enemy information systems while protecting own. There is a necessity to define operational and functional capabilities needed to achieve IS. Pursuing key IS technologies to develop a 'system-ofsystems' will pave the way for achieving IS.

(b) Electronic Warfare . Electronic Warfare is the capability to disrupt and degrade an enemy's defences and protect our own through the use of the electromagnetic spectrum including directed energy systems. It includes the capability of deceiving, disrupting and destroying the surveillance and command and control systems as also the weapons and sensors of an enemy's integrated air defence network. It should also include the capability to detect similar attempts by the enemy and initiate countermeasures and also protect own systems through redundancy and hardening.

(c) Area Missile Defence. Joint Area Missile Defence is the capability to use the AD assets to detect track, acquire and destroy incoming theatre ballistic and cruise missiles. It encompasses the seamless flow of information on missile launches by specialised surveillance capabilities, through tracking by the sensors of the services as also other associated agencies, to missile negation and destruction.

(d) Combat Identification. In any battlefield scenario it is imperative that the war fighter is able to have a clear and unambiguous awareness of the identity of all those present in the area. Modern technologies in surveillance sensors, communication & computing have enabled the task of achieving, sharing and maintaining battlespace awareness. The aim is thus to develop a capability with which we can positively identify potential targets as friend, foe or neutral in sufficient time with the highest possible level of confidence and at the requisite range to support weapon release and engagement decisions.

(e) Precision Force. This is the capability to destroy selected targets with precision using the information available through enhanced battlespace awareness and utilising the best-placed platform for ordnance delivery. It includes the requisite sensor to shooter C4 I capability for the responsive and timely application of such force, which includes the surveillance and targeting capabilities for the employment of Precision Guided Munitions (PGMs).

(f) Military Operations in Built-Up Areas (MOBUA). This is the capability to undertake operations in built-up areas so as to achieve military objectives with minimum casualties and collateral damage. It includes the appropriate precision weapons as also non-lethal weapons, surveillance sensors, navigation means and communication systems that are effective in confined, built-up urban areas. In a broad sense, our combat forces must be able to fight and survive better than their adversaries. The key operational capabilities required are firepower, force protection and manoeuvre. C4 I and the associated situation awareness would enable each of the operational capabilities.

(g) Combating Terrorism. This capability includes the capability to oppose terrorism throughout the threat spectrum including anti-terrorism (defensive measures to reduce vulnerability) and counter-terrorism (offensive measures to prevent, deter and respond).

This capability includes protection of personnel, assault, explosives detection and disposal, investigative sciences and forensics, physical security and protection of infrastructure, surveillance and collection. Support to land, sea, and air forces would be achieved by the use of improved detection, monitoring and tracking, intelligence and logistic communications, training and planning. The principal goal of Combating Terrorism is to protect lives and resources and allow forces the freedom of action required to accomplish assigned missions. Combating Terrorism leverages optimal utilisation of limited resources and focuses on technologies that offer significant improvement in force protection capability.

(h) Nuclear, Chemical and Biological Warfare Defence and Protection. The threats posed by the nuclear, chemical and biological warfare capability are a reality. There is thus a need to provide our forces with nuclear, chemical and biological warfare defence and protection. The requirement is to enhance joint warfighting capability so that our forces are capable of operating in an NBC environment both for offensive and defensive missions.

(i) Logistics Support. The capabilities which enhance mobility, deployability, and sustainability – attributes that are essential for the armed forces of 2010 and beyond cannot be achieved without a revolutionary change in concepts of logistics support. A Revolution in Military Logistics (RML) will have to be an integral part of any technological advance used to bolster warfighting capability by the enhancement of readiness for joint operations. There is a need to use technological breakthroughs to transform logistics into a distribution-based logistics system that substitutes logistics velocity for logistics mass. Technology has to be leveraged to fuse new organisational structures, concepts, transportation techniques, information systems, and logistics systems. This would fundamentally reshape the way the services are projected into operations and sustained thereafter.

Our acquisition process needs streamlining. We must reduce development time and acquisition costs for fielding critical technology to rapidly meet defence forces needs and remain viable in a constrained resource environment. Increasingly, advanced technology is becoming available on international markets, requiring DoD to accelerate the development process as never before. Rapidly transitioning technology from S&T to an operational capability is crucial. To speed up the technology transition process important mechanisms of S&T Development Technology demonstration and experimentation should be established to ensure the transition of innovative concepts and superior technology to the defence forces with speed and at affordable costs. Technology demonstration should be the key element in the S&T program to determine the military utility of proven technologies, expedite technology transition, provide a sound basis for acquisition decisions, and develop the concept of operations that will optimise effectiveness.

Partnerships

Partnerships are critical to a healthy S&T program. The Department of Defence is a partner with the following key entities:

(a) Academia and Research Institutes - for their new ideas and knowledge.
(b) DRDO – for their stability, long-term investments in S&T and focus on high-risk, high-payoff research.
(c) Defence PSUs and OFB for technology absorption.
(d) Private and Public Industry-for its innovation and transition of technology.
(e) Other Agencies - for their expanded resource base that leverages resources at the disposable of Department of Defence.
(f) International collaboration for technology development to allow us to address areas where indigenous R&D is weak/deficient.

Our S&T program should become stronger with institutional networking of stakeholders and increased public-private partnerships which will help reduce dependence on imports.

In peace, technological superiority is a key element of deterrence. In crisis, it provides a wide spectrum of options to the national command authorities and commanders in the field. In war, it provides an edge that enhances combat effectiveness, reduces casualties, and minimizes equipment loss. Focus on defence modernisation and availability of affordable military technology to the defence forces and ensuring that it undergoes rapid transition are critical national security obligations which need be fulfilled by Defence S&T Strategy.

BATTLEFIELD TRANSPARENCY

Battle field transparency in the new world dispensation is ever expanding both in terms of range coverage and the day/night capability. While contact battle primarily focuses on night capability, the depth battle moves a little further, looking for airborne/long range day/night all weather sensors. What ‘ability to fight’ at night is for contact battle, all weather day/night surveillance & target capability is for the depth battle.

Technology has been the driver of methods of war-fighting since the start of civilizations. The last century has been characterised by a phase where the rate of upgrade in technology has forced military leaders, planners and the scientist community to continuously adopt new paradigms and methods of war fighting. The interplay between technology and operational concepts has increased; in many cases technology has driven the operational concepts. It is imperative to develop weapons or surveillance devices that aid victory with minimum human cost.

Two recent benchmarks in high technology battlefield that merit special consideration are as follows:-

a. **Operation Desert Storm.** Operation Desert Storm was probably the first war wherein years of technology advancement outpaced operational concepts, and fresh doctrines and approach to warfare were practised and tested as the war progressed. The experience also brought out the criticality to build capacities in employment of technology both in terms of human interface or the operator skills and capacities to deal with larger amount of data for optimum utilisation of both 'battlefield transparency' and 'long range combat power'.
b. **Operation Neptune Spear**. The operation that finally nailed Osama bin Laden was a culmination of the employment of the most advanced surveillance systems in the world and hence can be taken as a benchmark for some time to come. The intelligence collection phase involved started from ground intelligence followed by the use of the most technologically advanced surveillance systems in the world—it involved the best of area and satellite surveillance tools; however again in the end ground intelligence was critical for final corroboration; thus reinforcing the importance of the human element to special technical tools. The actual operation phase involved the realtime information of progress available to the Presidential Command Post 7000 miles away. It reinforced the paradigm where a small military operation can have an operational or strategic context as the execution was enabled only by a high level of long range surveillance and acquisition technologies besides other technologies.
c. **Operation Desert Storm** provided the motivation to China to focus on technology and enter an age what the Chinese called 'informisation'. It redefined the scope of technology in conventional operations; the warfare paradigm again shifted after 11 September attacks wherein 'hybrid warfare' entered our military dictionary. Operation Geronimo demonstrated the level of technology and operations linkages demanded in a hybrid war scenario. The military and scientific hierarchy need to introspect how ready we are to execute a similar mission if the nation or situation so demands. No future war is likely to remain purely conventional and hence the need for surveillance and target acquisition to cater for both the hybrid and conventional domains. We as a nation need such a capability to be made available to the military.

The Indian Experience

Indian armed forces have in the last decade seen a quantum jump in surveillance technologies. Counter insurgency, especially in Jammu & Kashmir, the border fencing experience and hinterland security requirements have tested the efficacy of use of these by the military. In addition, the long mobilisation in Operation Parakaram highlighted the need to integrate surveillance and target acquisition. India has a formidable technological capability which needs to be optimised for operational employment. We are in a position to execute surveillance and acquire targets well in depth of the enemy. The continuous surveillance and intelligence collection or target acquisition process in peace is a precursor to what can be achieved in war.

There are several examples of a peace time information analysis of target areas. Better resolution, varied payloads, image analysis tools and finally ground intelligence form the complete matrix required to get results suitable for engagement ie to qualify to be termed under target acquisition. In this case development of our national assets for accurate target coordinates of target area in enemy territory are a challenge for the scientific community.

There are also examples of surveillance over a period of time for inputs on change in target profile. Different payloads can be employed to seek or substantiate information; task-specific imagery is obtained and analyzed. On identification of focus areas, fresh imagery is obtained using long range payloads which confirm/negate changes in the target profile.

Most examples are limited to satellite and aerial imagery for target acquisition. However, similar examples are equally relevant to electronic intelligence and ground based sensors. While such examples validate our technology capability there is no room for comfort as such examples are more as technology demonstrators. There is a long journey from technology availability to fully integrated operation military system. It is this arena of system integration where we need to build capacities. Building capacities include communication media for data/imagery transmission, softwares for analysis, operator training and sensor to shooter links.

The examples validate the capabilities available in India. However, there are large gaps in capabilities that need attention of the scientific community and the industry, which include

- Resolution capabilities for all kinds for imagery from radar to optical.
- Variety of payloads for imagery.
- Satellites for defence purposes, for which earlier capabilities had to be enhanced. Need for adequate revisit and repeativity capability.
- Electronic Warfare (EW) payloads have limitation of range due to the height from which it operates. Aerial platforms for such payloads will enhance the range and our reach.
- Numbers ie availability which affects timeliness.
- Crew availability as also the stations for imagery exploitation.
- Network structures to enable data handling and timeliness in converting surveillance input into target data for engagement.

An additional factor that has to be kept in perspective is the large dependence on imported surveillance equipment; no system caters for the diversity in terrain and weather conditions as experienced by the Indian soldier. It is therefore imperative we look for a combination of ToT (transfer of technology) and our Indian R&D to develop equipment suited to Indian conditions.

Division and Operational Level

The current capability profile at Div and Corps level include a wide variety of sensors and platforms; from ground based radars, LORRO S, TIIOE and EW assets to air based HMSS, UA Vs, aviation and IAF assets. Satellite imagery forms the top end of the surveillance profile. Special forces form the contact intelligence assets for depth surveillance and interdiction. TIIOF needs a special mention as a custom built target acquisition and engagement device which has distinctly improved capabilities of troops in contact; the tendency of using the equipment as a surveillance device needs to be guarded against.

Challenges at Operation Level

The challenges that merit attention of the scientific community and are an opportunity for the industry include the following:

- Networks. Networks guide speed of transaction of data and hence timeliness. Network involves communication links and data handling software—both are a specialisation which need to be custom made for the task, hence need to be developed in close coordination between users, scientists and the industry. Fast change in technology necessitates flexibility and continuous upgrade to provide the fighting soldier the best available.
- Passive Sensors. Passive sensors like sound ranging and EW equipment have high survivability compared to emitters. Modern systems duly tested to meet requirements of battle and pre contact phase in the field need to be fielded.
- Organisation structure to integrate multi sensor and multi agency inputs.
- Crew training and technology support to enable 24h surveillance and to cater for crew fatigue.
- Analysis Tools. The ability to glean actionable intelligence from mass of data has to be supported/aided by software like change detection and advanced filters to optimise inputs from a sensor.
- Accuracy of Coordinates. Acquisition of target coordinates with accuracy enabling engagement by long range/ beyond visual range precision equipment is a capability that has to be a forerunner to the development of high precision engagement system; it in this field that we need to focus to build indigenous capabilities. The accuracy of target coordinates is dictated by the CEP of the precision engagement weapons. While satellite imagery does give the ability to pick targets in operational and strategic depth of the enemy, ability to fix such targets to get accurate coordinates is a field which needs additional focus.
- Range. Commanders have always needed to look deeper, which necessitates moving sensors higher and higher. Masts for such sensors continue to be plagued by problems of stability and depletion in quality with sensor hardware separation.

Satellite Surveillance

While aerial surveillance was the forerunner of quantum upgrade in surveillance and target acquisition capability, satellite imagery brought it to another level which today has invaded our private or civil space. What few years back was a prized possession of advanced military forces is available to everyone including the terrorist at the click of a button. However military requirements in war have to meet the requirement of accuracy and timeliness; which is the area where we need to focus.

Our integral capabilities have largely been defined by the earlier TES, RISAT and now CARTOSAT 2B; for balance we largely rely on foreign satellite imagery. There is no need to stress that foreign imagery cannot be relied for during war and hence the need for integral capabilities. In terms of the requirements of the commander in field, well short of Geronimo and what we think is within our current capabilities today, can be said to include

- Resolution - sub-meter.
- Accuracy of coords - based on CEP of precision weapons.
- Availability time - 6h, to the field user. Mobile download stations upto Div level, in the interim at op level.
- Variety of payloads for day/night and all weather inputs.
- National imagery software - Bhumika with integrated softwares for military application.

Intra and Inter Services Issues

It has been well stated that numbers are a serious constraint in current surveillance grids. This enhances the need for optimizing the existing resources, which in turn impinges on us to ensure seamless cross-tasking and information sharing. This moves into challenges in communication compatibility, automation in seamless sensor tasking and information sharing, building capacities to enable imagery/data analysis, common designators and allied means of synergy within a service and inter-service. Laser target designators are a key area for precision targeting in the battle zone. Small teams primarily SF, which work on strict load limitations need to be empowered to do target designation by variety of laser guided munitions of the Air Force and Artillery, this demands development of a man-portable laser designator which is common to all types of delivery methods. Further, a partnership between the user and the scientific minds; especially the software and communication experts to enable sharing and cross tasking between the services is an area that needs focused effort.

Challenges in Mountain Terrain

Most of the equipment developed in last few decades in Europe and elsewhere has focused on mechanised warfare and mostly plains. India' ground realties are clearly different where most of our unresolved borders are mountains. A substantial portion of this is extreme HAA. Mountains by nature expose all equipment and the crews to harsher climatic conditions, extreme temperatures, reduced mobility and serious limitations on radar coverage & radio communications. The terrain naturally supports an adversary trying to make a stealth move. It is a natural corollary that Indian scientific community and industry has to work to adapt existing technologies as per the peculiarities of rugged mountainous terrain. This is an area where we seek fresh thoughts and capabilities.

Future

Armed UAV. Armed UAVs and drones epitomise the confluence of surveillance, target acquisition and engagement into a single platform; while the ethics of drone attacks in Af-Pak may a matter of debate, their effectiveness is largely uncontested. In conventional operations they could form mainstay of all high value target engagements; hence they are definitely a top priority in the wish list for the Indian military.

Hybrid War. Most surveillance systems that are being developed and deployed cater to a conventional war scenario. However our threats both in peace time and war have moved into the hybrid domain. Conventional war needs linear surveillance grids which have a reasonably well laid out FLOT ; surveillance focus and target discrimination is relatively easier compared to a hybrid situation. We are likely to encounter hybrid threats both within our own territory and in captured territories; this situation puts undermentioned challenges for the military thinkers to cater for the future needs. The future systems will need

- Advance FoF system for ground forces. Improved situation awareness of own forces.
- Increased automation to enable real time updates both of integral forces and surveillance updates from sensors.
- Automated tools to deploy surveillance sensors to grid coverage vis-à-vis a linear coverage; a fresh look at concept of surveillance. Increased synergy in various subsystems to provide a comprehensive picture; the fine balance between preventing fratricide and hitting enemy hybrid threats would need high reliability in situation awareness.

We can only reiterate the need for the three pillars of scientist– industry– soldier to integrate for building capacities in surveillance and target acquisition that would be the deciding factor of both the result and the human cost of the next war. Technology development and absorption specific to Indian conditions which will further our operational readiness has to be a continuous process. Specific projects to build surveillance capabilities, capacities to handle data and extract

accurate target data and effective networks have to move concurrently and in sympathy to achieve desired battlefield transparency.

COMMUNICATION SYSTEMS

On the rare occasion that strategic affairs experts in India write about the slow pace of military modernisation in India, they limit their lamentations to the ongoing deficiencies in the acquisition programmes of 'hard power' weapons and equipment like tanks, guns, missiles, ships, aircraft carriers, submarines, fighter aircraft, radars and surveillance systems. While powerful weapons platforms are obviously necessary for military domination and deterrence, supremacy in the battles of the 21st century will hinge on sophisticated command, control and communications systems that link the 'shooters' and 'sensors' together to achieve synergy through network centricity and effects-based operations.

It is in this field that modernisation has been grossly inadequate, particularly in the Indian Army. According to a former Vice Chief of Army Staff, the modernisation focus in the 11th Defence Plan is on "precision fire power, air defence, aviation, Future Infantry Soldier as a System (F-INSAS), infrastructure development, network centricity and achieving battlefield transparency through improved surveillance, night vision and target acquisition… Considering the receding span of technological cycle (sic), the right balance has to be maintained between state-of-art, current and obsolescent technologies." Despite this clear realisation about achieving the right balance, the Indian Army's communications systems are based mostly on obsolescent technologies. Software-based radios and cognitive radios are not even being talked about.

While some modern frequency-hopping radio sets with integral encryption devices have been introduced into service in recent years, networked communications, which form the backbone of an effective command and control system, need substantial upgradation. The Plan AREN system that is designed to roll forward and keep pace with offensive operations in the plains has been in service for almost three decades and is based on outdated and bulky technologies. It is based on outmoded second generation radio relay hubs and has no capacity for data transmission. Requests for Information (RFI) were floated for a Tactical Communication System (TCS) for offensive operations and a Battlefield Management System (BMS) for communication at the tactical level in defensive operations a few years ago, but since then the acquisition process has meandered continuously, resulting in prolonged delays in introducing both these systems into service.

The new optical fibre network being laid as an alternative to the 3G spectrum surrendered by the armed forces will go a long way in providing modern land-line communications. However, future communication systems will need to provide wide-band data capabilities to facilitate the real time transmission of images and battlefield video while on the move. The BMS will be integrated with the Army Static Communications (ASCON) system, which is the backbone

communication network of the army. ASCON provides voice and data links between static headquarters and those in peace-time locations. It is of modular design and can be upgraded.

TCS is a system that is meant for offensive operations – a mobile system that can 'leapfrog' forward as the operation progresses into enemy territory. The offensive operations echelons of the 'pivot' or 'holding' Corps deployed on the international boundary and the three Strike Corps will be equipped with TCS. The TCS programme has been delayed by more than ten years – the project was originally slated to have been started in the year 2000 and was hence called TCS 2000; now it is 2010 and yet the programme has not seen the light of day.

The Battlefield Management System (BMS) is meant for communications from the battalion headquarters forward to the companies and platoons. It will enable the Commanding Officer to enhance his situational awareness and command his battalion through a secure communications network with built-in redundancy. BMS involves big numbers and will be fielded both in the plains and the mountains. The number of infantry battalions alone is about 350. To this can be added 60 Rashtriya Rifles and 45 Assam Rifles battalions. When armoured, artillery, engineers and signal corps regiments, as also aviation squadrons and the logistics battalions are added, the numbers are really huge.

Both TCS and BMS have been categorised as 'make' programmes by the Defence Acquisition Council headed by the Defence Minister. This implies that the two systems must be designed and developed in India. The leading contenders are Bharat Electronics Limited, Tata Advanced Systems and Wipro, among others. Indian companies need to invest in developing the required technology and the ability to design and implement robust tactical communications systems. About 70 per cent of the required technology will have to be acquired from abroad and overseas companies will play a significant role.

Multinational Corporations with suitable technologies and the right experience to help as system integrators include General Dynamics, Thales and EADS. Indian companies planning to bid for these contracts must carefully evaluate the technological capabilities of these companies and how their systems have fared during recent combat operations, the type of experience they have in integrating tactical communications systems and whether they are likely to bring a long term commitment to the Indian projects. TCS and BMS will need to be compatible systems and the company that can supply state-of-the-art technology for both the systems at competitive prices will have a clear edge. In fact, it will be prudent for the Ministry of Defence to award both contracts to the same Indian company so that communications compatibility can be ensured in practice and not merely in theory from the very inception of the system.

The BMS communications system must also be compatible with the Future Infantry Soldier as a System programme. The F-INSAS project focuses on enhancing the lethality and survivability of soldiers. It seeks to transform soldiers into fully networked, mobile warriors with a high degree of situational awareness and the ability to operate in all weather conditions in all types of terrain.

The programme envisages equipping infantrymen with light-weight integrated helmets with a 'head up' display that has a built in communication system and night vision goggles, hand-held computer display, Global Positioning System (GPS) receiver and lethal fire power, including Laser-guided weapon systems at appropriate levels. The design and development responsibilities for both these programmes need to be clearly defined in order to avoid turf wars between the Infantry Directorate and the Information Systems Directorate in the Army.

According to a former Director General Information Systems, a Tactical Command, Control, Communications and Information (TacC3I) system is being developed by the Army. Under this mother system, various other systems such as CIDSS (Command Information Decision Support System), ACCCS (Artillery Combat Command and Control System), BSS (Battlefield Surveillance System), ADC&R (Air Defence Control and Reporting System), and BMS (Battlefield Management System) are being developed separately. Efforts are also underway to finalise a net-centric warfare (NCW) philosophy.

Little progress has been made towards addressing inter-Service interoperability challenges in the communications field. A tri-Service Defence Communications Network (DCN) is now under development and the proposals which have been received are being evaluated. Cyber security and offensive cyber warfare are other areas that do not appear to have received the attention that they deserve. With China moving rapidly towards creating "one million laptop warriors," neglecting this field will prove to be very costly in the long term.

The bi-annual DEFEXPO that is now underway has seen a 60 per cent increase in the number of participating companies because India is set to spend close to US$ 50 billion (Rs. 250,000 crore) on defence acquisitions over the next five years. The leading international defence manufacturers are making a beeline to New Delhi. The endeavour should be exploit technologies available internationally to design modern communications systems that are customised for Indian conditions and are in consonance with the Indian Army doctrine and the tri-Service doctrine.

India must skilfully leverage its buyer's clout to ensure that each defence acquisition contract results in the transfer of cutting edge defence technology to Indian companies. This is necessary not only for communication systems but also for all other weapons and equipment so that the country's technological threshold is raised by an order of magnitude. Future defence acquisitions must be firmly rooted in joint research and development with leading multinational corporations, joint trials and testing and joint manufacture and marketing. The patron-client, buyer-seller relationship in arms procurement in which India had been embroiled in the past must be consigned to history as a sorry chapter that is best forgotten. Also, the government must give up its monopoly on defence research and development except in sensitive strategic technologies.

ROCKET AND MISSILE SYSTEMS

Missile Technology

The development of missile technology in India started in the 1960s. Consider the following point relating to Missile Technology −

- The first successful testing of space-cum-missile technology was the Rohini-75, which was tested in 1967.
- The research and development program of developing indigenous missiles was called the Integrated Guided Missile Development Program'.

Types of Military Missiles

Based on target and launching position, the military missiles are classified as −

- **Air-to-Air Missile** − This missile is carried by an aircraft and targets the enemy's aircraft.
- **Surface-to-Air** − Such missiles are fired at enemy's aircraft from the ground.
- **Air-to-Surface** − These missiles are fired at the enemy country's ships, tankers, vehicles, bunkers, or military men from the aircraft.
- **Surface-to-Surface** − Such missiles are fired at enemy grounds from our grounds.
- **Underwater** − Such missiles target enemy locations in the water.

The idea of Integrated Guided Missile Development Program (IGMDP) was conceptualized by the former President and eminent scientist, Dr. APJ Abdul Kalam. The objective of this program was to enable India to attain self-sufficiency in the field of missile technology. IGMDP, is perhaps the first programme in India which brought together a large number of R&D laboratories, government departments, industries and academic institutions in the country within an integrated structure involving all the groups in a functional network. The programme was visionary and ambitious, aiming at the same time, deliveries to the Services as the end goal in a reasonable time frame.

The missiles proposed under this program are −

- **Prithvi** − It is a short-range surface-to-surface ballistic missile.
- **Trishul** − It is a short-range surface-to-air missile.
- **Akash** − It is a medium-range surface-to-air missile.
- **Nag** − It is a third generation anti-tank missile.

Agni Series

Agni is a series of medium to intercontinental range ballistic missiles. Agni missiles are medium-to-long range, nuclear weapons capable surface to surface ballistic missile.

In the series of Agni missiles, the first (Agni-I) missile was developed under the Integrated Guided Missile Development Program in the 1980s and it was first tested in 1989.

The Agni series of ballistic missiles is being developed under the Integrated Guided Missile Development Programme of the Defence Research and Development Organisation of India.

The Agni missile family consists of three deployed variants. The Agni-I, Agni-II and Agni-III are in service with the Indian Army. Agni-IV, the fourth in the Agni series of missiles, has completed all trials successfully by January 2017. A new intercontinental ballistic missile variant, the Agni-V, is also being developed and is expected to enter service by 2017-18.

The Agni-I is a short or intermediate-range ballistic missile. It was first tested at the interim test range in Chandipur off the coast of Orissa, India, in May 1989. The missile consists of a single engine. In March 2010, a nuclear-capable Agni-I was test fired from the integrated test range at Wheeler Island off the Orissa coast.

The Agni-II is a medium-range ballistic missile equipped with two solid fuel stages. It was test fired in April 1999 from the IC-4 pad. The nuclear-capable Agni-II was tested by a special strategic command force in May 2010. The missile has a range of more than 2,000km and can reach most of the western, central and southern parts of China. A tank missile with top-attack, fire and forget capability was also inducted into service.

The Agni-III was test fired in July 2006 from Wheeler Island, but failed to reach its target. It was successfully test fired in April 2007. A third test in May 2008 proved the operational readiness of the missile. With a circular error probable under a 40m range, the missile is considered one of the most accurate strategic ballistic missiles of its range class in the world.

The Agni-IV has a length of 20m and weight of 17t. It can carry a payload of 800kg. The maximum range of the missile is 4,000km.

The following table lists down the different Agni missiles with their features −

Name	Type	Range	Status
Agni-I	Medium-range ballistic missile	700 – 1,250 km	Operational
Agni-II	Medium-range ballistic missile	2,000 – 3,000 km	Operational

Agni-III	Intermediate-range ballistic missile	3,500 – 5,000 km	Operational
Agni-IV	Intermediate-range ballistic missile	3,000 – 4,000 km	Operational
Agni-V	Intercontinental ballistic missile	5,000 – 8,000 km	Testing
Agni-VI	Intercontinental ballistic missile	8,000 – 10,000 km	Under development

Prithvi

The Prithvi was India's first indigenously developed ballistic missile. The Prithvi is not a particularly sophisticated missile, incorporating propulsion technology derived from the Soviet SA-2 surface-to-air missile.

First test-fired on February 25, 1988, two versions of this single-stage, liquid-fuel missile are now in service and a third may be in development. Prithvi-I (150 km/1,000 kg) in army service, is capable of striking about a quarter of Pakistani territory, including Islamabad and most other major cities. Prithvi-II (250 km/500 kg), in Air Force service, could strike at least half of Pakistan, including almost all military targets of importance and all major cities. Development of a longer-range, reduced-payload Prithvi-III (350 km range) is suggested by some sources. The Prithvi-lll is apparently the naval version of the missile.

The mobile launcher, mobile launch control and user version of the ground system including software, have been validated. Reportedly, the Prithvi-I can be armed with five different types of conventional warheads. A prefragmented warhead has been developed which has performed satisfactorily in dynamic and static trials.

Starting with a test on 27 January 1996, the Prithvi-II missile has been tested to achieve the range of 250 km with a 500-650 kg payload. On 23 February 1997 India conducted the third test of the Prithvi-II, the 16th in the overall program. And on 16 June 2000 India completed successfully its 17th test firing of the Prithvi. On 13 December 2001 India tested an improved version of the Prithvi missile from the at Chandipur testing. The medium-range missile was fired over the Bay of Bengal from the testing range, 750 miles southeast of New Delhi.

It is suspected that nuclear missions would be executed by the Prithvi-II. Prithvi does not have nuclear warheads, and India has consistently stated that Prithvi is to be conventionally armed.

Although little has been written about the Prithvi's accuracy, India claims that it is the first indigenously produced missile with inertial guidance. Prithvi is reported by some sources to have a circular error probable of 1.5 km. — 1% of range, and therefore it cannot be categorized as a precision munition. According to other sources, the accuracy of the Prithvi when fired from a pre-surveyed launch site is 10 meters at a range of 67km. From an unsurveyed site, that increases to 150-200 meters at 150km.

Akash Missile

The Akash Missile is a medium range Surface to Air Missile with multitarget engagement capability. It uses high-energy solid propellant for the booster and ram-rocket propulsion for the sustainer phase. The propulsion system provides higher level of energy with minimum mass, compared to conventional solid/liquid rocket motor, that has better performance with minimum weight of the missile.

It has a dual mode guidance, initially on command mode from a phased array radar and later radar homing guidance with unique software developed for high accuracy. The phased array radar provides capability for multiple target tracking and simultaneous deployment of missiles to attack four targets at the same time, in each battery. Multiple batteries constitute a group centre. The system is highly mobile and has gone through a number of flight trials providing the command guidance.

Trishul Missile

The development of Trishul missile was completed by DRDO. Trishul was completed as a "Technology Demonstrator" due to delay in development of state-of-the-art technology and changes in requirement of the Armed Forces.

Trishul is intended to counter a low level attack with a very quick reaction time and has an all weather capability. Trishul has a range of 9 km and is designed to counter a low level attack with a very quick reaction time. It is all all-weather surface-to-air-missile which call, when employed with the fire Control Flycatcher radar, blow a hole in the enemy's plan. With a radar-altimeter in its warhead, Trishul can be used as an anti-sea skimmer missile. Trishul has been extensively tested by all three Services for target acquisition, ground system and infra-red guidance system. The Trishul Combat Vehicle, the indigenous launcher system using radar mounted on a tracked vehicle, has gone into production.

It flies in supersonic speed and has a low altitude sensitive radio-altimeter and height lock loop control onboard, to skim over the sea at a very low altitude and hit against sea skimming missiles coming towards our ships. The tracking and guidance have been fully achieved in millimetric

band frequency and has necessary electronic counter measures. Defence Research and Development Organisation laboratories, BEL, BHEL, BDL and many other industries and naval establishments are partners in the development of the vertically launched Naval-TRISHUL system.

By 1998 Trishul had undergone over two dozen developmental flight trials, and the missile was inducted into service in 1999. Trishul will be employed by Indian Army and Air Force against low flying aircraft. The Indian Navy will also use this weapon system in anti-missile role against Exocet and Harpoon possessed by Pakistan.

The Naval version of the short-range Surface-to-Air Missile, "Trishul", was successfully flight tested at Kochi on 28 and 29 Jan 2002. The missile was tested in sea-skimming mode against low flying targets, establishing the capability of the system in the 'anti sea skimmer' role.

Nag Missile

Nag is a third-generation, fire-and-forget, anti-tank guided missile developed by India's state-owned Defence Research and Development Organisation (DRDO) to support both mechanised infantry and airborne forces of the Indian Army.

The missile incorporates an advanced passive homing guidance system and possesses high single-shot kill probability. It is designed to destroy modern main battle tanks and other heavily armoured targets.

Nag can be launched from land and air-based platforms. The land version is currently available for integration on the Nag missile carrier (NAMICA), which is derived from a BMP-2 tracked infantry combat vehicle. The helicopter-launched configuration, designated as helicopter-launched NAG (HELINA), can be fired from Dhruv advanced light helicopter (ALH) and HAL Rudra (ALH WSI) attack helicopter.

The Nag missile was indigenously developed under the Indian Ministry of Defence's integrated guided missile development programme (IGMDP. Bharat Dynamics (BDL) produced imaging infrared seekers for the weapon. The first test of Nag was conducted in November 1990. A test launch of the missile from a tube in programmed control mode was performed at the Interim Test Range, Balasore, Odisha in September 2001.

User trials of the Nag anti-tank missile against static and moving targets were conducted in 2007 and 2008 respectively, while the development tests were concluded in August 2008. Seeker evaluation tests for the missile were conducted at the Pokhran Test Range in Rajasthan in July 2013. Tests on the HELINA were carried out at the Chandan Firing Range in Rajasthan in July 2015.

The Nag anti-armour guided weapon's airframe is built with lightweight and high-strength composite materials. The missile features top-attack capability and has high immunity to countermeasures. The missile is equipped with four foldable wings and has a length of 1.85m, diameter of 0.20m, wing span of 0.4m and weight of 43kg. A blunt nose cone houses the guidance system, while the middle portion accommodates a compact sensor package and the main charge of the warhead. A booster rocket motor is located towards the rear. Four tail fins are fitted at the rear to stabilise the missile while in flight.

A real-time image processor with fast and efficient algorithms is installed next to the guidance section to provide automatic target detection and tracking capabilities. The digital autopilot offers guidance, stability and control for the missile during the flight. Nag is also outfitted with an electric actuation system for flight control.

A passive imaging infrared (IIR) homing seeker guides the missile to the target after its launch in all lighting conditions. The missile can be optionally offered with a millimetre wave active radar seeker. An 8kg tandem-shaped charge high-explosive anti-tank (HEAT) warhead, with a precursor and a main charge, provides the weapon with a high kill probability. The precursor charge penetrates the explosive reactive armour (ERA) of the tanks and the main charge is intended to destroy the main armour.

Astra Missile

Astra is India's first beyond-visual-range (BVR) air-to-air missile indigenously designed and developed by Defence Research and Development Organisation (DRDO). It is intended to engage and destroy aerial targets with high manoeuvrability and supersonic speeds. The missile's advanced air combat capabilities allow it to engage multiple high-performance targets.

Astra was planned to equip the Indian Air force's Su-30MKI and Mirage 2000 multi-role combat fighters, and MiG-29 and MiG-21 Bison fighter jet platforms, as well as the Indian Navy's Sea Harrier jet fighter. It will also be integrated with the Tejas light combat aircraft (LCA), which is manufactured by Hindustan Aeronautics Limited (HAL). The highly agile, accurate and reliable missile features high single-shot kill probability (SSKP) and is capable of operating under all weather conditions.

The length of the weapon system is 3.8m, while its diameter is 178mm, and an overall launch weight is160kg. Its low all-up weight provides high launch range capability and the system's airborne launcher can be used with different fighter aircraft. The electronic counter-countermeasures (ECCM) feature improves the missile's target tracking capability by reducing the effect of electronic countermeasures of the enemy targets in jamming environments.

Surya Missile System

The Surya Missile or Agni 6 is an intercontinental ballistic missile under development by the DRDO for the use of the Indian Armed Forces. Surya will be a four-stage intercontinental ballistic missile. Surya Missile will carry a massive three-tonne warhead, thrice the weight of the one-tonne warhead that Agni missiles have carried so far. This will allow each Agni-6 missile to launch several nuclear warheads -Multiple Independently Targetable Re-entry Warheads (MIRVs) – with each warhead striking a different target. Each warhead – called Maneuverable Reentry Vehicle (MARV) – performs evasive maneuvers while hurtling down towards its target, confusing enemy air defence missiles that are trying to destroy them mid-air. And these maneuverable warheads will give Agni VI an extended range exact figure of which is currently classified. It will be taller than its predecessor Agni V, and is expected to be flight tested by 2017. Agni-VI missile is likely to carry up to 10 MIRV warheads and will have a strike range of 8,000 km to 12,000 km.

The guidance system of Surya Missile or Agni 6 will include inertial navigation system with Ring laser gyroscope, optionally augmented by IRNSS. Terminal guidance with possible radar scene correlation (this is a kind of terrain contour mapping this improves the accuracy of missiles).

Fire and forget Missiles

Fire-and-forget is a type of missile guidance which does not require further guidance after launch such as illumination of the target or wire guidance, and can hit its target without the launcher being in line-of-sight of the target. This is an important property for a guided weapon to have, since a person or vehicle that lingers near the target to guide the missile (using, for instance, a laser designator) is vulnerable to attack and unable to carry out other tasks.

Generally, information about the target is programmed into the missile just prior to launch. This can include coordinates, radar measurements (including velocity), or an infrared image of the target. After it is fired, the missile guides itself by some combination of gyroscopes and accelerometers, GPS, organic active radar homing, and infrared homing optics. Some systems offer the option of either continued input from the launch platform or fire-and-forget.

Development of Anti Missile Systems

India has been trying to develop an indigenous ballistic missile defence (BMD) system since the late 90s. The recent missile test by DRDO is one step in that direction. India has added Israel's SPYDER system to its air defence system and has bought S-400 system from Russia (to be inducted in India's BMD system) which will be delivered in 2020. S-400 has the capability to

defend against both endo-atmospheric and exo-atmospheric threats. An endo-atmospheric missile remains within the earth's atmos spheric missile remains within the earth's atmosphere, below 100 km altitude, while an exo-atmospheric missile can fly out of the atmosphere too.

India already has Prithvi, a high-to-low level anti-ballistic missile. Prithvi I is used by Army and has a range of 150 km, Prithvi II is used by Air Force and it has a range of 350 km while Prithvi III, which is used by Navy, has a range of 350 km. Another missile in India's BMD system is Ashwin (Advanced Air Defence missile) Ashwin has been designed to intercept incoming enemy missiles at an altitude of up to 30 km. The US, Russia, Israel and China have advanced BMD systems.

BrahMos

The BrahMos is an antishipping weapon—it also can hit ground-based targets, and is ideal for precision attacks against fixed installations such as radars, command centers, airbases and enemy missile batteries. It can also potentially carry a 660-pound nuclear warhead, though that doesn't appear to be its primary intended use. There are quite a few variants of the BrahMos missile designed to be used by the different platforms of the Indian military against either land or naval targets.

The Indian Navy's BrahMos missiles mostly use eight-cell Vertical Launch System launchers. Six of its frigates and two destroyers have a single BrahMos launcher, while three of its destroyers have twin launchers. More BrahMos equipped ships are under construction. The Navy has also successfully tested in 2013 a submarine-launched version which is expected to enter service in future vessels. Submarine-launched BrahMoses could potentially be launched fairly close to the target without being detected.

BrahMos began in the 1990s as a joint project between Russia and India to develop an Indian version of the P-800 Oniks cruise missile. The missile's name is a portmanteau of the rivers Brahmaputra and Moskva in India and Russia, respectively.

Even more importantly, the BrahMos's ability to maintain supersonic speeds while skimming at low altitude makes it very difficult to detect and intercept. To cap it off, the BrahMos performs an evasive "S-maneuver" shortly before impact, making it difficult to shoot down at close range. A modern ship targeted by the BrahMos could respond with layered defenses to shoot down the missiles: ripple-fired medium- and short-range antiaircraft missiles and close-range CIWS. But an effective attack would involve firing multiple missiles in order to overwhelm these defensive countermeasures.

BrahMos claims it has the capability of attacking surface targets by flying as low as 5 meters in altitude and the maximum altitude it can fly is 14000 meters. It has a diameter of 70 cm and a

wingspan of 1.7 m.[106] It can gain a speed of Mach 2.8, and has a maximum range of 290 km. The ship-launched and land-based missiles can carry a 200 kg warhead, whereas the aircraft-launched variant (BrahMos A) can carry a 300 kg warhead. It has a two-stage propulsion system, with a solid-propellant rocket for initial acceleration and a liquid-fuelled ramjet responsible for sustained supersonic cruise.

The high speed of the BrahMos likely gives it better target-penetration characteristics than lighter subsonic cruise-missiles, such as the Tomahawk. Being twice as heavy and almost four times as fast as the Tomahawk, the BrahMos has more than 32 times the on-cruise kinetic energy of a Tomahawk missile, although it carries only 3/5 the payload and a fraction of the range, which suggests that the missile was designed with a different tactical role. Its 2.8 mach speed means that it cannot be intercepted by some existing missile defence systems and its precision makes it lethal to water targets.

Although BrahMos was primarily an anti-ship missile, the BrahMos Block III can also engage land based targets. It can be launched either in a vertical or inclined position and is capable of covering targets over a 360-degree horizon. The BrahMos missile has an identical configuration for land, sea, and sub-sea platforms. The air-launched version has a smaller booster and additional tail fins for added stability during launch.

LIGHT AIRCRAFT

Tejas

India's Light Combat Aircraft (LCA) together with its variants, is the smallest and lightest Multi-Role Supersonic Fighter Aircraft of its class. This single engine, Compound-Delta-Wing, Tailless Aircraft is designed and developed by ADA with HAL as the principal partner along with DRDO, CSIR, BEL, DGAQA, IAF & IN to meet diverse needs of the Indian Air Force (IAF) and Indian Navy (IN).

The LCA has been designed and developed by a consortium of five aircraft research, design, production and product support organizations pooled by the Bangalore-based Aeronautical Development Agency (ADA), under Department of Defense Research and Development Organization (DRDO). Hindustan Aeronautics Limited (HAL) is the Principal Partner in the design and fabrication of the LCA and its integration leading to flight testing.

Tejas is an aerodynamically unstable tailless compound delta-wing configuration, optimized primarily for maneuverability and agility. Designed to meet the tactical requirements of a modern air force, Tejas is a multi-role aircraft capable of comprehensive air superiority and air defense roles.

The smooth upper wing body blending of Tejas gives it enough Stealth to avoid early detection. This kind of upper body blending is only being seen in later generation fighters. This high wing body blending is the hall mark of even the fifth gen fighters, reducing the corner reflections from the awacs radars searching from above resulting in lower RCS with missiles and external sores hidden under the wing.

Another stealth feature of Tejas is its Y intake also called bifurcated intake. Engine fan blades are one of the prominent sources of increasing radar cross section. This Y intake buried the jet engine inside the fuselage so no engine parts are visible and thus increases the stealth characteristics.

Tejas incorporates a highly reliable quadruplex digital fly-by-wire Flight Control System. Digital fly-by-wire flight control system eases the handling by the pilot. The digital FBW system of the Tejas employs a powerful digital flight control computer (DFCC) comprising four computing channels, each with its own independent power supply and all housed in a single LRU

The new generation glass cockpit of Tejas comprises Multi Function Displays (MFD), Head Up Display (HUD) and Stand by Instrumentation System driven by Open Architecture Mission and Display Computer. This provides effective Human Machine Interface (HMI). The advanced utility and health management system provides system health and warnings to the pilot through an Open Architecture Computer (OAC).

Tejas will feature the AESA radar. Currently it uses the EL/M 2032 radar in its MK 1 version. Tejas MK 1A will use EL/M 2052 AESA radar and indigenous UTTAM AESA radar is under development. Due to the small nose cone, AESA in Tejas obviously have a lower range, but it will be well integrated with in the IAF network, and give a quantum technology jump to IAFs combat ability.

Saras

India's homegrown 14-seater aircraft Saras has been re-engined and modified is expected to take off for the first time in the first week of June 2017.

The original design included a maximum takeoff weight of 6,100kg and a maximum payload of 1,232kg. The first prototype which completed its maiden flight on May 29, 2004, was overweight at 5,118kg compared to the 4,125kg design specifications.

Although the plane was conceived as a civil aircraft, NAL has been pushing Saras for military certification. Saras will now boast of multi-role capabilities like feeder line aircraft, air ambulance, executive aircraft, troop transport, reconnaissance, aerial survey and light cargo transport.

Dhruv ALH

The Helicopter Division of the government-owned Hindustan Aeronautics Limited (HAL) has developed the Dhruv (Pole Star) advanced light helicopter (ALH), a light (5.5t class) multirole and multimission helicopter for army, air force, navy, coastguard and civil operations, for both utility and attack roles by day and night. The helicopter, which is built to FAR 29 specifications, entered series production in 2000.

The army received its first three Dhruvs in March 2002. By June 2008, 76 helicopters had been delivered to the army and air force with 159 more on order. The Indian Navy has decided not to place any further orders. The fleet of the Indian Air Force Display Team, Sarang (Peacock in English) includes the Dhruv helicopters.

In June 2008, HAL received the first export order for the Dhruv – seven helicopters for the air force of Ecuador. In August 2006, Indian Air Force and Coast Guard Dhruv helicopters were instrumental in rescue operations after devastating floods in India. Over 500 people were rescued.

The advanced technologies incorporated in the Dhruv design include anti-resonance vibration isolation system (ARI), full authority digital electronic control (FADEC), hingeless main rotor, bearingless tail rotor, and an automatic flight control system.

Hindustan Aeronautics Limited and Israel Aircraft Industries have an agreement to market the Dhruv helicopter worldwide. IAI has developed an integrated helicopter avionics suite for the Dhruv, which includes day-and-night observation, electronic warfare suite, observation and targeting, and a flexible weapons carrying system. The helicopter is of conventional design and about two-thirds by weight of composite construction. The high tail boom allows easy access to the rear clamshell loading doors. The four-bladed hingeless main rotor can be manually folded. The blades are mounted between cruciform-shaped carbon-fibre-reinforced plastic plates on a fibre elastomer constructed rotor head.

The helicopter is equipped with an active vibration control system developed by Lord Corporation of North Carolina that uses sensors to monitor on-board conditions and outputs signals to actuators to cancel fuselage floor vibrations. The aircraft is equipped with a SFIM Inc. four-axis automatic flight control system.

The navigation suite includes a global positioning system, a Doppler navigation system, distance measuring equipment, a true air speed indicator, automatic direction finder, a heading reference system, radio altimeter, VHF omnidirectional ranger and instrument landing system (VOR/ILS) and marker beacons. The communications suite includes HF, UHF, and VHF radio communications.

The army and air force helicopters have stub wings fitted to carry up to eight anti-armour missiles, four air-to-air missiles or four rocket pods for 70mm and 68mm rockets. The naval variant can carry two torpedoes or four anti-ship missiles.

Advanced Jet Trainer

Licensed production by Hindustan Aeronautics is an important part of the AJT requirement, which included 42 from HAL assembly, following 24 from the original constructors in the planned initial batch of 66 aircraft. The need for an AJT was first articulated by the IAF in 1982 and ever since has remained high on IAF's agenda for procurement. The IAF felt that there existed a quantum difference in the skill and judgement levels required of a yong fighter pilot as he transited to state of the art fighters such as the Su-30 MKI, Mirage 2000 and MiG-29. The Hawk 132 would adequately serve as lead in trainer for these advanced aircraft.

The idea of the trainer was mooted in 1983, the Air Staff Requirement prepared next year and after government approval in 1986, a joint IAF-HAL-DRDO team evaluated the British Hawk and Franco-German Alfa Jet.

The AJT program came close to fruition by early 1996, but the Russian MiG-AT trainer [which had not been fully developed] was added to the shortlisted aircraft Alfa jet and Hawk. Four years later, the MiG-AT failed to materialise. Production was slated to begin in 2001, with the first of the AJTs being delivered somewhere around 2004. The UK Government continue to support British Aerospace's efforts to export up to 60 surplus Hawk aircraft trainers to India, but, as of late 2001 the decision rested with the Indian Government.

Subsequently, the Indian air force agreed to buy 66 Hawk trainer fighter jets from the UK. In February 2003, India awarded a $1.7bn contract to supply the trainer fighter jets to the UK company, BAE Systems. The Hawk beat a rival bid from a state-run Czech firm. India would buy 24 Hawks outright and build the rest under BAE licence in the southern city of Bangalore.

The Hawk AJT – which India finalised after a 20-year drawn out drama – encountered turbulence shortly after it was selected by the IAF. Upset over Britain's inability – or perhaps unwillingness – to supply spares to HAL, which is assembling the Hawk in India, the IAF shelved plans to place follow-on orders and instead floated a new tender in 2009.

The Indian Navy inducted the Hawk 132, a fourth generation Advanced Jet Trainer aircraft, on 06 November 2013 Four aircraft had been delivered to the Navy, marking the beginning of seventeen such fighter trainers to be acquired over the next few years.

By September 2016 India was poised to place an order for an additional batch of Hawk advanced jet trainers under a Rs 3,500-crore deal to meet requirements of the Air Force and Navy. The new deal for 32 jet trainers would add to the 123 aircraft already ordered for the Indian armed

forces. The Navy had a requirement of at least eight more Hawks to train fighter pilots for the MiG 29K fleet, and the Air Force required additional planes for its Suryakiran aerobatic team that had been reconstituted after a long break.

By early 2017 India had contracted 123 Hawk Mk-132 AJT aircraft from BAE Systems for the IAF and the Navy. Another order for 20 aircraft to equip the Surya Kiran aerobatics team was in an advanced stage. HAL was assembling the Hawks in India under a license.

Lakshya

Pilotless Target Aircraft (PTA) (named as Lakshya) is a reusable aerial target system. Lakshya is remotely operated from ground to provide aerial target for training of gun and Missile crew and Air Defence pilots for all the three Services. Delivery of five Lakshya systems with 26 operational flights for Air Force have been accomplished in 2001-2002. The first batch of Lakshya has already been delivered to the Navy. Three aircraft with Ground Control and Support System have been handed over and four operational flights have been conducted. Phase-I delivery for Army is planned shortly.

Lakshya is a remotely piloted aerial vehicle designed and built by Aeronautical Development Establishment (ADE), a subsidiary of the Defence Research and Development Organization (DRDO), for the Indian Armed Forces. A total of 23 Lakshya units are currently operational with Indian Defence Services.

A reconnaissance version of Lakshya is being built. It will be fitted with electro-optic cameras, digital onboard computers and Satcom datalink to carry out autonomous operations. An advanced model called Lakshya-2 is also being developed by ADE. The variant can fly at very low altitudes ranging between 15m and 20m for testing guns and missiles. It will be available in land recoverable and sea recoverable versions.

Lakshya is a reclaimable aerial target system designed to train gun and missile crews and air defence pilots in engaging targets. It was designed to launch either from land or sea through a zero length launcher and be recovered by a dual stage parachute system. Designed to be reused for 15 missions, the aircraft can spiflicate airborne incoming enemy targets.

The Lakshya features a breakable nose cone, air target imitator, infra-red sensor and synthetic aperture radar. It is equipped with a target towing unit under wing pylons to train crews of anti-aircraft guns and missiles. A JATO rocket booster weighing 145kg is installed to enable smooth take-off.

The avionics suite installed in the Lakshya includes flight control electronics (FCE), electro-mechanical actuators, vertical gyro, acoustic miss distance indicator (AMDI) and CW doppler. The AMDI measures the miss distance of projectiles and assesses performance and proficiency

of the artillery crew. The Lakshya is powered by a single PTAE-7 turbojet engine rated at 3.7kN of thrust. The engine is designed and manufactured by HAL in Bangalore. It features a four stage transonic axial flow compressor, single stage turbine, an annular flow combustion chamber, digital electronic fuel control system and 16 fuel flow burners. The length and diameter of the engine are 1.27m and 0.33m respectively. The dry weight is 65kg.

Nishant

The DRDO Nishant is an Unmanned Aerial Vehicle (UAV) developed by India's ADE (Aeronautical Development Establishment), a branch of DRDO (Defence Research and Development Organisation) for the Indian Armed Forces.

The Nishant UAV is primarily tasked with intelligence gathering over enemy territory and also for reconnaissance, training, surveillance, target designation, artillery fire correction, damage assessment, ELINT and SIGINT.

Nishant is one of the few UAVs in the world in its weight-class capable of being catapult-launched and recovered by using parachute, thus eliminating the need for a runway as in case of conventional take-off and landing with wheels. The keel was laid down in September 1988 when DRDO would take the decision for indigenous development of UAV by seeing the requirement of ARMY for the remotely piloted vehicle.The Nishant RPV made its first test flight in 1995. In July 1999, for the first time the Indian army deployed its new Nishant UAV system in the fight against guerilla forces backed by Pakistan in Kashmir.

The Nishant makes use of a conventional aircraft arrangement and follows well-accepted UAV design Form-particularly for low-altitude operations requiring extended loitering times and stability for its on board optics payload.It features a central nacelle making up its fuselage which contains avionics and payload as well as power plant and fuel stores.Wings are straight appendages mounted high atop the fuselage.

The tail consists of a twin-boom structure joined at the rear by a single horizontal plane,outboard this plane are vertical tail fins.Optics are held in a positional blister assembly located along the belly.

The UAV has a length of 4.63 m ,wingspan of 6.57 m and carry a payload of 45 kg.The UAV can be used in battle field as for reconnaissance & surveillance purpose and it has a capability to perform operations in night also. The Nishant UAV also features Target tracking and localization,Artillery fire correction and Target designation (using integral laser target designator).The vehicle has all terrain mobility and has endurance of 4 hr 30 min

The 380 kg (840 lb) Nishant UAV requires rail-launching from a hydro-pneumatic launcher and is able to be recovered by a parachute system. The Mobile Hydro-Pneumatic Launcher (MHPL)

system mounted on a Tatra truck weighs 14,000 kg (31,000 lb) and boasts of a life cycle of 1000 launches before requiring overhaul.The truck serves in other militarized forms and is a proven battlefield component,providing the Nishant with essentially all-terrain accessibility.

The Nishant UAV is powered by 1 x RE-2-21-P or RE-4-37-P engine that drives a two-bladed propeller in a "pusher" arrangement at the rear of the aircraft. The Nishant has maximum takeoff weight of 275 kg. The UAV launches at the velocity of 45 m/s in the time interval of 0.6 second with the powerful 100kW engine.The UAV has maximum speed of 185 km/h and cruise speed of 125 km/h to 150 km/h.The vehicle has range of 160 km and service ceiling of 3600 m.

Arjun MBT

Main Battle Tank (MBT) Arjun is a multi-laboratory programme of DRDO with CVRDE as the lead Laboratory. It is a state-of-the-art tank with superior fire power, high mobility, and excellent protection. Twelve Mk 1 prototypes of MBT Arjun have been manufactured and their performance tests have provided satisfactory results. Some of the breakthroughs achieved by CVRDE during the development of MBT Arjun are in Engine, Transmission, Hydropneumatic Suspension, Hull and Turret, and Gun Control System.

The superior armour defeating capability of the indigenously developed Fin Stabilized Armour Piercing Discarding Sabot (FSAPDS) ammunition and 120 mm calibre rifled gun give MBT ARJUN an edge over contemporary world tanks. A computer-controlled integrated fire control system incorporating day-cum-night stabilized sighting system guarantees a very high first round hit probability and reduced reaction time to bring effective fire on targets.

The stabilization system for the main armament, slaved to the sighting equipment in elevation and azimuth, with a high and accurate laying speed, allows fire on the move.

The superior fire power of MBT is based on:

- Accurate and fast target acquisition capability during day and night and in all types of weather .
- Shortest possible reaction time during combat engagements.
- Ability to accurately engage targets on move.
- Capability to destroy all possible enemy armour at maximum battle ranges.
- Excellent first hit probability.

The rifled 120 mm ARJUN gun together with the newly developed super velocity ammunition, can defeat any contemporary armour used in tanks. The electro-slag refined gun steel tube is autofrettaged to withstand higher gas pressures. A thermal jacket prevents irregular temperature distribution on to the tube due to the weather influences.

A co-axial 7.62 mm machine gun for anti-personnel and a 12.7 mm machine gun for anti-aircraft and ground targets are provided as secondary weapons.

Due to the high power-to-weight ratio and low specific ground pressure, MBT is fast, highly manoeuvrable and extremely mobile to cross the most difficult terrain with ease. High acceleration rapid braking capabilities with excellent steering characteristics make MBT agile in the battlefield. Adequate fuel storage capacity and relatively low fuel consumption allow for an optimal operational range.

An important criterion for the mobility of any AFV is the effective performance of the driver. Excellent vision systems both for day and night provide most effective means of observation in all battlefield conditions. The need to keep the crew's fatigue including that of driver at the minimum level over long periods of continuous operation, have been taken care of.

Ergonometry, using anthropometric data of Indian troops, has been kept in view while designing the fighting and driving compartments to fully exploit the outstanding features of the weapon system. Hydropneumatic suspension provides excellent ride comfort for crew eliminating fatigue even on the extended runs.

Pinaka

The Pinaka Multi Barrel Rocket Launcher System, is a state of the art weapon for destroying/neutralising enemy troop concentration areas, communication centres air terminal complexes, gun/rocket locations and for laying mines by firing rockets with several warheads from launcher vehicle. High operational mobility, flexibility and accuracy are the major characteristics, which give Multi Barrel Rocket Launcher System an edge in modern artillery warfare.

The indigenously built Pinaka multi-barrel rocket launcher Weapon Area System can fire rockets with a range of 39-40 km, in a salvo of 12 rockets with 1.2 tons of high explosives within 40 seconds. The complete systemcomprises a launch vehicle, a loader / replenishment vehicle, and a command post vehicle with a battery of six launchers.

Pinaka can neutralise a target area of 350 square kilometres, and is meant as a supplement to the existing artillery system at a range beyond 30 km. It can be fitted with a variety of warheads ranging from blast-cum-pre-fragmented high explosives to anti-tank mines. This indigenously designed MLRS is far cheaper than the international competition, costing just Rs 23 million per system. By comparison the American M270 MLRS costs Rs 195 million, and the 9P140 URAGAN of Russia and the ASTROS-II of Brazil each cost Rs 38 million.

The Armament Research and Development Establishment (ARDE) has also developed a high performance artillery rocket system which can fire within a range between 70 km to 100 km.

This is a highly sophisticated "shoot-and-scoot" high mobility system capable of firing a salvo of 12 rockets, each with a payload of 100 kg within a time span of 30 seconds. This new artillery rocket system comprises of an advanced family of warheads including terminally guided submunitions with autonomous target search and engagement capability besides remotely delivered intelligent bomblets and minelets with self-neutralising capability.

In late April 2005, India test-fired multiple rounds of the Pinaka multi-barrel rocket system at Chandipur. The tests were reported to be aimed at improving the entire system and sub-system of rockets.

A single Pinaka I launcher with 12 rockets can neutralize a target area of 3.9 km2. Pinaka is a complete MBRL system, each Pinaka battery consists of: six launcher vehicles, each with 12 rockets; six loader-replenishment vehicles; three replenishment vehicles; two Command Post vehicle (one stand by) with a Fire Control computer, and the DIGICORA MET radar. A battery of six launchers can neutralize an area of 1000 m x 800 m. The Army generally deploys a battery that has a total of 72 rockets. All the 72 rockets can be fired in 44 seconds, taking out an area of 1 km2. Each launcher can fire in a different direction too. The system has the flexibility to fire all the rockets in one go or only a few.

The 'submunition warheads' which had been successfully tested for Pinaka I in Pokhran field firing range during June 2015 would be used in Pinaka II as well which is going to act as a force-multiplier while supplementing the artillery guns as well.

Despite complaints of faulty ammunition, India's Ministry of Defence (MoD) spent $490 million on 36 Pinaka Mark-1 multi-barrel rocket launchers, manufactured by the country's own Defence Research and Development Organization (DRDO).

The Pinanka-1 will replace the Indian Army's Soviet-era regiment of Russian-made Grad BM-21 MBRL systems. The new system will have a 40 kilometer (nearly 25 mile) range. New Dehli is awaiting the arrival of the Pinaka-2, which will feature an increased range of up to 60 kilometers. Though Pinaka-II was successfully test-fired at the Pokhran field firing range in May 2015, the development schedule for that project is unclear.

DIRECTED ENERGY WEAPONS

If there is a single dominant factor that has changed the course of warfare in human history, it is technology. Technological advances in weaponry, intelligence gathering, guidance system, propulsion systems, and more, have helped evolve new war strategies and doctrines which have revolutionized the conduct of warfare at various stages in history. The most significant and pervasive influence of technology on warfare is being witnessed in the current evolution of new systems. Unfortunately, in the Indian case, the experiences with the Defence Research and

Development Organization (DRDO) have prompted the services to look for only foreign purchases whenever it wants to upgrade any technology. Due to this, there will perhaps always be a quantum of difference between the technologies which are specifically required and that which are finally made available.

Within a decade or so, the Indian Air Force (IAF) will replace its legacy aircraft, the erstwhile MiG-21.The replacement will be a variety of superior fourth-generation aircrafts. Most of these will be multi-role, hence frequent changing of configuration will become a thing of the past. However, it must be noted that no matter how advanced an aircraft is, its basic role is still that of a platform to carry weapons. The effective punch of any generation of aircrafts is the weapon it wields. Hence, the induction of improved weapons to match the advanced platform should be the focus to enhance effectiveness. It should not be forgotten that the lethality of the enemy air defence system has also improved simultaneously. Therefore, exposing a sophisticated platform without utilitarian weaponry will not prove to be cost effective. There is a need to have a precision and stand-off capability in any air weapon of today. Such systems may not be readily available or, if available, may not be parted with by the concerned country of origin. In any case, there are only two options to remain ahead in the arms race: either have a cooperative foreign partner whose interests match yours or develop your own potential to produce weapons.

As per current estimates, we will have 270 Su-30MKI, 126 medium multi-role combat aircraft (MMRCA) and 40 Tejas by 2020. Yet, these superior aircraft would continue to function with weapons many generations behind. As the IAF is slowly shedding its old skin and taking on a new garb, it is also time to add a new set of teeth which will give a lethal force to its bite. The need of the hour is a weapon which can take on multiple targets from a stand-off distance, one with a magazine that lasts longer than the endurance of the aircraft and which has the capability to take on missiles launched at supersonic or hypersonic speeds. Such a weapon needs to be developed in-house so that it can form a part of our force expansion process for a longer period with many modification in its entire life cycle.

The lifespan of a modern weapon system is in the region of 30 years which is normally extendable by another 10–15 years after a mid-life upgrade. New equipment procured for the IAF over the next decade will remain operational up to 2050, possibly up to 2060 at most. As the nature of warfare itself is undergoing transformation, it is necessary to make a comprehensive reassessment of the contours of the operational scenario that the IAF will have to contend with and reconfigure its inventory accordingly. To do this at this point in time, the IAF needs to take note of India's regional power status in the emerging world order and assess its possible role and responsibility in the new geopolitical and geostrategic environment. The IAF's sister services are also faced with a similar dilemma.

DEW—The Sharper Cutting Edge

Development of directed energy weapons (DEWs) and creation of weapons on electromagnetic pulse effects without a nuclear blast are likely to change the course of future warfare. A DEW emits energy in an aimed direction without the means of a projectile. It transfers energy to a target and introduces uneven heat stresses, leading to failure of structural integration of the target and causing its destruction. This weapons effect on humans may be changed from lethal to non-lethal. The DEWs broadly encompass two fields which are: high-energy lasers (HELs); and highpower microwaves (HPMs)—millimeter waves and microwaves.

HEL has gained more emphasis at present due to ease in deployability and low operational cost as compared to other options. It is also a very popular choice due its varied use against different targets. This article is an attempt to justify undertaking its development in context of inducting it into the Indian armed forces.

Why DEW?

According to military planners, the conventional 'blast and fragmentation' weapons have reached their pinnacle as far as further technological developments are concerned.

The inherent characteristics of the DEWs give it some distinct advantage over today's existing kinetic energy weapons (KEWs). Pursuing development of a DEW is attributed to the following unique properties:

- Travels at the speed of light (greater than all the future, present and past conventional weapons) and no complicated calculation for target movement necessary.
- Not affected by gravity (no trajectory calculations required).
- Can be invisible and silent; attacker remains concealed.
- Duration for deployment—a few seconds to a minute—reduces exposure of launcher to enemy position.
- Recharging of magazine non-existent, only source of energy required.
- No recoil as there is no momentum, so equipment mountings need not be large.
- Operation range larger than conventional weapons.

All is Not Well

However, the above-mentioned properties are not all-encompassing; there are some restrictions which can make DEWs non-effective, and they can be used as measures to counter a DEW attack.

- The target has to be in the line of sight of the laser.

- Due to divergence, an inherent property of a beam of light, the range gets restricted to a few 100 km and not beyond. Technological advances are being worked out to increase range.
- Presently, the requirement of energy source is large, but with advancement in superconductivity and nanotechnology, this problem is being worked upon.
- The beam can be scattered by creating a smoke screen over the target, placing reflective surfaces, spraying water, etc.

Is it a Weapon of the Future?

Not exactly, because it cannot be the only weapon. It will have to coexist and complement the KEWs considerably. But over the long run the non-DEW option would have a detrimental effect for any nation. The rapid advancement in the information and communications technology (ICT) and nuclear technology will pose a major challenge for any defence force in the future. The only weapon capable to disable, deny, damage or destroy a nuclear weapon as well as an ICT equipment is the DEW. This makes it a viable choice for the future.

Hypothetical Scenarios

Consider a hypothetical scenario in which two countries are in conflict. Well aware of the value of asymmetric weapons, one country begins investing in DEWs and equips its armed forces with these weapons. In the event of an unwanted war, for defensive protection, they intend to use HPM sources to disrupt the other country's stealth aircraft, which are potentially more susceptible due to their wave-absorbing nature. Moreover, they plan to protect their own fighter aircrafts with free electron laser (FEL) cannons against incoming missiles and shoot down the other's rockets and artillery fire with tactical high-energy laser (THEL) from the arsenal of a multi-platform, multi-mission defence system. For offensive applications, this directed energy-conscious nation suppresses the other's air defence and command, control, communications, computer and intelligence (C4I) facilities with unmanned air vehicles (UAVs) loaded with radio frequency (RF) weapon payloads. Using a modularized sealed exhaust chemical oxygen iodine laser (COIL), they can disable the other's critical domestic infrastructure, transportation and communications systems with advanced tactical laser (ATL). In addition, agents use transient electromagnetic devices (TEDs) to cause detrimental effects on infrastructure such as financial institutions (that is, banks, ATMs and stores), airport facilities and other critical entities.

The second country underestimates DEW attacks by prioritizing conventional fighters and cruise missiles against their enemy's defences. With the unique role of DEWs' combination of rapid reaction times, long ranges and speed-of-light engagement, unlimited magazine and precision, this second nation is susceptible to DEW attacks that can destroy its aircraft and missile systems.

The HPM signals from the directed energyequipped adversary's installations cause over 90 per cent of cruise missiles to fail en route to their targets. Following a directed energy-equipped nation's attack with an E-bomb, airborne laser (ABL) and/or advanced tactical lasers, there is little left of this second country's ground facilities and airborne defence systems, with the added condition that minimal collateral damage resulted from the directed energy-equipped country's attack. So, which country do we want to be is a question we need to ask ourselves.

DEW as a Tri-Service Weapon

Recent advances in technologies have made the development of DEWs technically feasible. After the third quarter of the last century, scientists offered many logical and convincing explanations about why DEWs will be a dominant force in the coming years. Although early documents categorize particle beams as DEWs, later studies just examine laser and HPMs under the directed energy umbrella and do not include particle beams in the discussion. All the sources found in academic journals highlight the importance of DEWs and how they will change the battlespace perspective of future wars. While some sources present these weapons simply as reflections of technological improvements, other researchers offer more complicated and technical discussions. Most current scientific studies discuss just one type of DEW and, at this point in time, do not include military applications in the discussion. Military writings mostly view these weapons with just one service branch's point of view—army, navy or air force. Envisaging the role played by our defence services in the future, DEWs can be broadly described as per the specific service.

Air Force

The goal of the IAF is to become a force with a 'strategic reach', both in peace and war. A major responsibility of the IAF in the future would be in the area of strategic power projection. Given its emerging regional power status and the newly formed strategic partnership with the US, if not abrogated by the incoming administration, India may be called upon to project power in the region. This may involve highly sophisticated technology or low but effective technology. In either case, it should possess a weapon which, in any scenario, can give the IAF superiority once it has undertaken a policing role. Strategic weapons other than those for mass destruction need to be developed and used. In-house expertise with the involvement of the IAF would, therefore, need to be built up practically from scratch, as no such technology currently exists within the country to develop this kind of weapon.

This weapon will, in turn, enhance the effective potency of the IAFs force multipliers already on its inventory. At the strategic level, it will provide the nation with credible nuclear deterrence against its adversaries. It will also increase the capability of power projection in perceived areas of national security and in interest of our allies in regions beyond national borders. For strategic strike deep into enemy territory, the IAF needs to have a combination of satellite-based and long-

endurance, airborne platform-based DEW—the latter with powerful electronic warfare equipment to suppress and defeat enemy air defence systems. Tactical roles may be transferred to unmanned combat aerial vehicles (UCAVs) and helicopters at later stage when the equipment size can be reduced (with nanotechnology and superconductivity).

To provide effective air defence of the homeland, the IAF needs to acquire a fleet of Airborne Warning and Control Systems (AWACS) and Airborne Early Warning (AEW) aircraft, over and above the few already on order, to enhance surveillance capability at low level. These large-bodied aircrafts can be modified to incorporate the DEW system and act as search and destroy platforms. There is a need to introduce new-generation area and point-defence systems to replace the ageing and obsolete systems currently deployed. These new systems can also be incorporated with the newly developed DEW system which will prove to be more effective. The DEW is capable of being used as an area weapon by taking on multiple targets, one after another. Its capability as a precision weapon is, of course, flawless. For strategic and tactical intelligence, the IAF must have its own satellite systems which, if developed in-house, can be mounted with a DEW system to have effective coverage of potential targets from space (presuming that the stigma attached to weaponization of space is made more pragmatic by the time these weapons are developed).

Navy

Analysing the possibility of equipping the Indian Navy surface ships with DEWs in coming years raises a number of potential issues for the future naval planners. The Navy faces serious anti-ship cruise missile threats to surface fleet. The two aircraft carriers are our most expensive and valuable assets. They stand vulnerable to cruise missile threats from any nation who can afford or has access to buy them. Protection of the carriers and larger ships against SS-N-22 Sunburn (Russian origin) or its Chinese equivalents would be a formidable task. This particular missile is capable of a 320 kg warhead, Mach 3 speed at high altitude and a sea skimming low-altitude Mach 2.2 speed with an effective range of 250 km. Reaction time at a distance of about 15–25 nm (28–45 km) or less to ship will be 25–60 seconds. In such a scenario, the use of DEW may certainly prove to be a viable possibility. The issues which the Navy needs to deliberate upon are:

- Whether the Navy should act now to adopt a programme for developing a production version of a shipboard DEW and/or make a road map that calls for developing DEWs for specific threats which its perceives in the future (as its plans till 2022 do not have any mention of such issues).
- What type of DEW may suit the existing power supply and other prerequisites required for generation of DEW on a ship, keeping in mind the available technology in shipbuilding in the Indian dockyards?
- The potential implications of ship-borne DEWs for maintaining sea control in the Indian waters.

In addition to decisions on whether or not to fund development of potential shipboard DEWs, the Navy or some other organization needs to perform an analysis of alternatives (AoA) comparing the cost effectiveness of DEWs and traditional kinetic weapons (such as missiles and guns) for countering surface, air and missile threats from 'Sunburn' and its equivalent class of missiles.

Army

India is not likely to face a military threat from the US or China because of its strength, both military and economic. A medium-level military threat may arise from Pakistan if it fails to make adequate economic and political progress, or its leadership passes to radical elements or the country, as such, fails and lapses into a state of anarchy. Such engagements may have the following characteristics.They will be of short duration, say, a week or less. Penetration in depth is unlikely to be attempted by either side. 'Cold Start' will be attempted whenever possible to achieve surprise and maximize gains. The entire border is likely to be activated with shallow thrusts, very heavy firepower and short-span manoeuvres. Nuclear weapons may not be used; their use may, however, be threatened. Special Forces and coup-de-main forces will play a major role. Integrated action by all three services will be crucial for the enhancement of our combat power vis-à-vis that of the adversary. Levels of technology employed in the wars will be higher than at present. Wars will end in stalemate, with little or no gain, and military as well as civilian targets will face heavy losses. However, in the skirmishes, the danger of unarmed civilian casualties will be great and will need to be handled with firmness and imagination.

The cost involved and the casualty are the two factors which need to be paid attention to in case of the Army. Huge loss of trained manpower and expensive equipment requires greater effort to replace. The introduction of DEWs can play a major role in reducing both drastically. Avoiding the exposure of our own troops to the ranges of enemy fire and inflicting considerable damage to the enemy from stand-off distance of close to 100 km will indeed prove to be much more cost effective.

The Fourth Front

Operation Desert Storm in 1991 gave rise to the use of space as a military asset. This success prompted the US to use space more effectively in Operation Iraqi Freedom in 2003. More than 100 satellites were used in various roles to give an added advantage to the allied forces as far as collection and dissemination of information was concerned. These two operations gave rise to the era of space weaponization. Today, the global positioning system (GPS) and other information-providing assets are all space-based. Space-based assets enhance the capabilities of sea-, airand land-based forces. The use of space is gradually shifting from force enhancement to force application, which is applying force directly onto targets.

A great boost was given in this direction by the ambitious plan initiated by US President Ronald Reagan in 1983 known as the 'Strategic Missile Defence'. The proposal was to use space-based lasers and particle beams to intercept and destroy incoming missiles. The project could not be sustained for long and was finally abandoned in 1993, but the technology developed during this time is now being used to give better and more effective results. This has given the US a three-decade head start, but many nations like Russia, China and France are slowly catching up in development of this technology. Our own Indian Space Research Organization (ISRO) has also not done badly—it has developed one of the largest constellations of satellites, the cheapest launch capability, and has made India one of the few nations to have sent an unmanned moon mission. The problems lies in it following a 'not-so-objective-driven' path in development in space. One way to look at this is that no national aim or goal has been given to them, so, in turn, they are working to satisfy their scholastic needs. We have the capability but we need to define our national objective more clearly. Missions such as the unmanned moon mission should give some strategic advantage to the nation.

The US, of course, has been in the forefront in the use of space as a future arena. They have an ambitious plan to attain space superiority. They have gone ahead in identifying what are called 'liberation points' (L4 and L5), which are essential to gain control in space. As per the doctrine, 'Whosoever rules space commands planet earth; whosoever rules the moon commands space, and who rules L4 and L5 commands the earth–moon system'. The L4 and L5 are points in orbit where the gravitational forces of the earth and the moon are equal, thereby providing a parking slot for spacecraft with minimal use of power. With such aggressive postures taken towards space weaponization, the control of orbital space and with it, control of space and thus, the domination of earth will become an operational necessity in the coming years.

The various operations in space can largely be qualified as space safeguard operations: protection of space-based assets; counter space operations, that is, denial of space to an adversary; and space attack operations—using space-based weapons on terrestrial or space-based targets, and also from land on to space targets. Space-based assets comprise mainly of various kinds of satellites. As per latest estimates, there are about 3,000 of these presently orbiting the earth. Among them, some may be for the GPS system, some for spying and the higher-orbit ones are for geostationary purposes like communication, information and other allied purpose. The low-orbit satellites do not pose a problem as far as their destruction is concerned. This aspect has been proved by the recent successful attempts made by the US and China in destroying their own life-expired satellites with ground-based aircraft with a highrange precision air-to-air missile. The problem lies in taking on the higher-orbiting satellites. These are the ones which create the main hub of information dissemination and provide steady flow of data in real time. Information will impact the wars of the future much more than they ever did in the past. If the source of information can be targeted, then achieving dominance in information warfare will prove to be easier.

As mankind starts thinking of waging war even in space, there are calls for preserving the sanctity of space. The present treaty, commonly called 'Outer Space Treaty', does specify the so-called restrictions on using weapon other than the nukes. It limits the use of the moon and other celestial bodies to only peaceful purposes. It, however, does not prevent the use of a technology which can have a dual use: one which is peaceful upfront but can be turned into a weapon when selected to do so. This treaty thus allows nations to deploy weapons other than nuclear weapons in space. The development of any new weapon which is non-nuclear in nature can be pursued.

The DEW, being a laser-oriented weapon without any nuclear connection, can be developed and deployed in space. It will prove to be very effective when used against either low-orbiting or high-orbiting satellites. This kind of weapon will definitely provide dominance of space with its use for all the three space operations, namely, space safeguard, counter space operations as well as space attack operations.

Up till the last century, dominance of air was the key to dominate land. Today, the envelope has moved to the fourth dimension—space. The future war's fate will be decided by whosoever dominates this dimension. The DEW provides an incomparable advantage in this dimension of warfare.

Plan of Action for Indian Defence Forces

The next 10 years may see the emergence of DEWs as an operational capability in the US defence services. These weapons may have the unique capability of attacking targets at the speed of light and are likely to significantly impair the effectiveness of many weapon types, especially ballistic weapons.

Institutional Approach

What this actually highlights is that India (and in turn, the Indian defence forces) cannot waste 40 years in research and development (R&D) as the major concepts as well as prototypes have already been developed and are available in other parts of the world. What needs to be studied instead is an institutionalized approach to develop DEWs technology by taking advantage of the already developed principles and concepts. This effort may have to involve DRDO, the services (it can, for example, can be driven by them), academicians (universities, Indian Institutes of Technology [IITs] and other engineering colleges), private industry (could involve an external consultation agency like KPMG, Associated Chambers of Commerce and Industry of India [ASSOCHAM] and Confederation of Indian Industry [CII]) which act as a single integrator, ordnance factories, etc. The Modular Open Systems Approach (MOSA), presently known as the Open Systems Architecture (OSA) system, can be an option adopted to ensure that no delay takes place like in the other research works undertaken by DRDO. The OSA can ensure coordination of multiple vendors who may supply subsystems that may connect to the main

assembly through combinations of military and open industry standard hardware and software. Therefore, subsystems can be developed, in parallel, by multiple contractors and be interchangeable between the prototypes as they are tested to avoid delay in major assembly production. This may ensure a faster route to production than what is being followed in our present defence production units.

A probable phase-wise distribution of the project can be as follows:

- Phase I, which can include four lines (as per the required hardware for producing a DEW, that is, lasing medium, energy source, mirrors and lens) prefixed with firm price contract, with a designated time of completion (this can specifically be defined after discussion with all the stakeholders). This phase may be focussed on conceptual designs.
- Phase II may provide for more detailed design and development work in a predetermined time period after the first phase is over. This phase should have at least two systems going forward to the prototype stage.
- Phase III, running between two to three years from the end of phase II, may involve manufacturing, assembly and testing of the DEW(s).
- Phase IV may see deployment in the IAF, Indian Navy or the Indian Army, as the case may be, for testing and field trials.

The funding and coordination agency can be the service headquarters which monitors the progress through an autonomous body like Aeronautical Development Agency (ADA) (Air Force), and similar agencies in the other two services.

This research work can be carried out by any designated agency after laying the broad guidelines and defining the responsibility of various agencies which may implement the project for the Indian defence forces. The broad framework in which the research may take place is as follows:

- Evolving the requirement based on the threat perceived.
- Feasibility of transition from science and technology into acquisition and deployment.
- Facilitating systems integration.
- Leveraging commercial investments.
- Suggesting ideas to reduce the development cycle time and total life cycle cost.
- Giving recommendations to ensure that the system may be fully interoperable with all the systems which it must interface, without major modifications of existing components.
- Suggesting areas where commonality and reuse of components among systems can take place.
- Suggesting a road map to enhance access to cutting-edge technologies and products from multiple suppliers.
- Suggestingmethodstomitigatetherisk oftechnology obsolescence and single source of supply over the life of the system.

Warfare is largely unwanted, but often unavoidable. Under the shadow of this reality, innovations in technology and the application of that technology to military operations combine to provide an opportunity to gain military advantage. The rate of technological change in communications, computers, sensors, lasers and RF weaponry is influencing and increasing the complexity of modern warfare. Military communities have known of the detrimental effects of RF energy on electronics since World War I. As electronics devices are making modern weapons more accurate and deadlier than ever, the directed energy weaponry approach appears to be the most promising counter to this in the next 20 years or so. Although the subject is highly technical and requires a scientific approach, I have tried here to explain the necessity as well as the demands of DEW as a paramount requirement for national security in the future. The advantages far outweigh the disadvantages of DEWs. Being a new concept, it will not be easily accepted without criticism against its cost and long gestation. The need of the hour, however, is a visionary approach to our future security requirements and keeping in mind the changing weapon scenario; it will be a crucial decision either way. Today's decision will pay dividends after 30 years.

The time is right, and the focus needs to change to allow the nation to retain the deterrence capability which it enjoys now. The neighbourhood is already launching a massive technological drive for bringing about improvement in its arsenal. The power equation in the next 20–30 years may tilt in India's favour depending on today's decision. Our defence forces are the best as far as human qualities are concerned; however, we need to give them the best weapons to take them to the pinnacle of force standards. The success of this article would lie in triggering the minds of the change makers to start implementing the process to catch up with the advancement in weapon technology. The concept of service–private sector–academicians is a new aspect which needs to be developed to generate better project management techniques, especially in a country plagued with project/cost overruns. The OSA concept has benefitted other countries and the induction of this technology may prove beneficial for India and may set a standard path to avoid project overruns in other national projects.

MILITARY INTELLIGENCE

Artificial intelligence (AI) also known as machine intelligence (MI) is intellect displayed by computer system (or machine), in contrast with the natural intelligence (NI) displayed by humans and other animals. Given the complexity involved in application of AI in both military and civilian spheres, a working definition of AI is required. There is no one commonly decided definition, even among computer scientists and engineers, but a general definition of AI is the capability of a machine to perform tasks that normally require human intellect, such as visual perception, speech recognition and decision-making.

To better understand the nuances of AI, it is important first to understand the difference between an automated and an autonomous system. An automated system is one in which a computer reasons by a clear if–then–else, rule-based structure, and does so deterministically, meaning that for each input the system output will always be the same (unless if something fails). An autonomous system is one that reasons probabilistically given a set of inputs, meaning that it makes guesses about best possible courses of action given sensor data input. Unlike automated systems, when given the same input autonomous systems will not necessarily produce the exact same behaviour every time; rather, such systems will produce a range of behaviours.

While there are many parallels between human intelligence and AI, there are stark differences too. Every autonomous system that interacts in a dynamic environment must construct a world model and continually update that model. This means that the world must be perceived (or sensed through cameras, microphones and/or tactile sensors) and then reconstructed in such a way that the computer 'brain' has an effective and updated model of the world it is in before it can make decisions. The fidelity of the world model and the timeliness of its updates are the keys to an effective autonomous system.

How AI can help the Indian Armed Forces

Of all the purported uses of Artificial Intelligence (AI), it would be hard to find one more controversial than its possible use for military purposes. In popular consciousness, the idea of military AI immediately brings to mind the notion of autonomous weapon systems or "killer robots", machines that can independently target and kill humans. The possible presence of such systems on battlefields has sparked a welcome international debate on the legality and morality of using these weapon systems. The controversies surrounding autonomous weapons, however, must not obscure the fact that like most technologies, AI has a number of non-lethal uses for militaries across the world, and especially for the Indian military. These are, on the whole, not as controversial as the use of AI for autonomous weapons, and, in fact, are far more practicable at the moment, with clear demonstrable benefits.

For the Indian military especially, these potential uses of AI could prove to be exploitable low-hanging fruit to quickly and effectively enhance its technological capabilities. Put together, there are three areas where AI can be readily deployed without much controversy or effort.

First, logistics and supply chain management. This is arguably the lowest of the low-hanging fruits available to the Indian military. Substantial work has already been done in deploying AI for logistics and supply chain management in the civilian sector, with several Indian companies also having built considerable expertise in this area. It would, therefore, not require much effort to transfer the technology, knowledge and expertise already present in the civilian space to meet the military's needs. An efficient logistics system lies at the heart of any well-functioning military, and this is especially complicated for the Indian Armed Forces given the diverse

environments and conditions they operate in. AI-backed systems could go a long way in increasing efficiencies, reducing wastage and overall costs in the military's logistics management.

Second, cyber-operations. As cyber warfare becomes faster, more sophisticated and more dangerous, it becomes necessary to develop both offensive and defensive cyber-war capabilities both to protect the military's own assets and communication links, and to attack similar assets of opposing militaries. Specifically trained AI systems could actually prove to be far more efficient and effective than humans for such tasks. The scale and speed of the responses necessary in evolving cyber-operation domains make it unlikely that humans will be able to tackle evolving threats in an effective manner by themselves. A number of cybersecurity experts and commentators believe that AI is the future of cyber-operations, with machine-on-machine engagements increasingly becoming the norm, especially to counter low-order or routine threats.

Third, intelligence, surveillance and reconnaissance (ISR). This has already been put into practice by various countries, including the US, and, possibly, China. Using AI for ISR tasks can take two different forms. The first is the use of AI in unmanned vehicles and systems, whether on air, land, or on and under water. This includes increasingly ubiquitous drones but also unmanned ships and submersibles and ground vehicles. Such "intelligent" unmanned systems could be used for patrolling in harsh terrains and weather conditions, providing harbour protection, and allowing the deploying force to scout the battlefield or conflict zone with no danger to human soldiers. The second use is for data analysis and interpretation. An AI system could, for instance, be trained to pick out predetermined suspicious behaviour from the video footage of a surveillance drone, and thereby identify potential targets. Much of this work is currently done by humans, but the time taken and possible data under-analysed is immense. AI could do in a few hours what would have taken a human days to do, and in a significantly more efficient manner. This fact has led the US to develop and deploy an experimental system called Project Maven, which analyses video footage from drones to identify potential threats in the US' fight against the Islamic State (IS).

The three specific use-cases discussed above are the very low-hanging fruit that can be exploited with the existing technical and manpower capabilities. The incorporation of these AI systems in the functioning of the Indian military could potentially lead to a long-term reduction in costs, while improving its technological capabilities. Further, the technology for each of these use cases is already present in some form principally in the civilian space.

To fully exploit their potential, however, the Indian military needs to build a close working relationship with the vibrant private technology sector in India, and especially with start-ups doing exciting work in the AI space. This will inevitably involve handing over potentially sensitive data to private firms so as to enable the building of AI systems that can meet the specific needs of the Indian Armed Forces. This is entirely uncharted territory in India, and to assuage the valid concerns that may arise with sensitive data being in private hands, a unique

legal “trust model" needs to be built that accounts for the needs of the military and technological innovation. While the development of such a model may, in fact, prove to be a tougher task than the simple integration of AI technologies, it needs to be done if the Indian military is to prepare itself for warfare in the 21st century.

Overview of China & US AI Capabilities

China

By 2020, China’s overall progress in technology and applications of AI are expected to keep pace with the world’s advanced level, while its AI industry becomes an important economic growth point. By this time, China hopes to have achieved important progress in next generation AI technologies, including big data, swarm intelligence, hybrid enhanced intelligence, and autonomous intelligent systems. At that point, the value of China’s core AI industry is targeted to exceed 150 billion RMB (over $22 billion) in value, with AI-related fields valued at 1 trillion RMB (nearly $148 billion). Concurrently, China is advancing in gathering top talent and establishing initial frameworks for laws, regulations, ethics, and policy.

Next, by 2025, China plans to achieve major breakthroughs in AI to reach a leading level, with AI becoming a primary driver for China’s industrial advances and economic transformation. By then, China intends to become a leading player in research and development, while widely using AI in fields ranging from manufacturing to medicine to national defense. China’s core AI industry should have surpassed 400 billion RMB (about $59 billion), with AI-related fields exceeding 5 trillion RMB (about $740 billion). In addition, China plans to have achieve progress in the creation of laws and regulations, as well as ethical norms and policies, along with the establishment of mechanisms for AI safety assessment.

The Chinese leadership is advancing an “innovation-driven” strategy for civilian and military development, aiming to become the world’s “premier innovation center” in AI by 2030.Certainly, a range of challenges, including serious shortcomings in human capital, may inhibit progress, and China presently continues to lag behind the United States in cutting-edge research and development. However, China’s rapid rise and future trajectory in AI could be enabled by critical systemic and structural advantages, including likely levels of funding and investment, potential human talent resources, and massive amounts of data. AI is a high-level priority within China’s national agenda for military-civil fusion and this strategic approach could enable the PLA to take full advantage of private sector progress in AI to enhance its military capabilities.

China’s recent advances in Swarm Intelligence—which involves autonomous cooperativebehavior among masses of distributed robots—have been on prominent display in official media. In June 2017, China Electronics Technology Group Corporation, a state-owned

defense conglomerate, successfully flight-tested a swarm of 119 drones—a new record. In a conflict, the PLA could use swarms to cheaply target high-value U.S. weapons platforms, such as aircraft carriers.

USA

US Government is spending billions of dollars preparing for the next stage in warfare that it believes will be defined by advances in AI. Concepts like Motherships of drones releasing little baby drones from the air and the sea, infantrymen and women sporting exoskeletons and wearable electronics loaded up with combat apps, and lone mission commanders directing swarms of unmanned vessels to carry out operations are already being tested at MIT's Computer Science and AI Laboratory.

On May 3, 2016 the US Administration announced the formation of a new National Science and Technology Council (NSTC) NSTC Subcommittee on Machine Learning and Artificial intelligence, to help coordinate Federal activity in AI. This Subcommittee, on June 15, 2016, directed the Subcommittee on Networking and Information Technology Research and Development (NITRD) to create a National Artificial Intelligence Research and Development Strategic Plan. A NITRD Task Force on Artificial Intelligence was then formed to define the Federal strategic priorities for AI R&D, with particular attention on areas of national security that industry is unlikely to address.

In the last few decades, one of the largest sources of funding for AI research came from the Defense Advanced Research Project Agency (DARPA), which is agency of the Department of Defense of the United States of America responsible for the development of new technologies for use by the military. The DARPA Virtual Machine Reality(VMR) system aids intelligence analysts in searching, filtering, and exploring visual media through the use of advanced computer vision and reasoning techniques. The goal of DARPA's VMR program is to extract mission-relevant information, such as the who, what, where and when, from visual media captured from adversaries and to turn unstructured, ad hoc photos and video into true visual intelligence.

What has India done so far?

The Ministry of Defence (MoD) constituted a multistakeholder task force for Strategic Implementation of Artificial Intelligence and Defence in February 2018 that submitted its report in June. The MoD implemented the recommendations by providing an institutional framework for policy implementation, issuing guidelines to the defence organisations, and laying out a vision for capacity-building.

In February 2019, the ministry established a high-level Defence AI Council (DAIC) under the chairmanship of Minister of Defence assigned with the task of providing strategic direction towards the adoption of AI in defence. The DAIC will guide the partnership between the government and industry and also review the recommendations concerning the acquisition of technology and startups. It also envisions the formation of a Defence AI Project Agency (DAIPA) as the central executive body.

The ministry ordered to focus on the capacity building within defence machinery. The tasks range from the knowledge production in the form of data collection, patents etc to acclimatising the personnel on-duty through internships, training programmes and sabbaticals. Each Service Headquarter (SHQ) will be provided with a window of Rs 100 crores for AI specific application developments from the ministerial budgetary allocation. The task force recognised AI as a 'force multiplier' and emphasised that all the defence organisations lay down their strategies of AI appropriation.

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As discussed earlier, robotics is also one of the ways to achieve AI. The Centre of Artificial Intelligence and Robotics (CAIR) in the Defence Research and Development Organisation (DRDO) has also developed autonomous technology-based products. It has focused on the net-centric communication systems for tactical command control. For surveillance and reconnaissance purposes, CAIR has developed intriguing probes like snake robots, hexa-bots, and sentries. It has a comprehensive library for AI-based algorithms and data mining toolboxes that can potentially be used for image/video recognition, NLP, swarming. However, in a data-based approach to artificial intelligence, efficient learner algorithms can only serve a limited purpose without the hardware that can collect and process a large amount of data.

Few questions to be addressed

The key challenges for the adoption of artificial intelligence, in general, are elucidated in the Niti Aayog's 2018 document titled 'National Strategy for Artificial Intelligence #AIforAll.' In addition to this, there are many challenges that AI brings up in the military sector.

Firstly, policymakers must have a sound understanding of the objectives that AI seeks to achieve in the strategic context of India to disseminate artificial intelligence in defence. What kind of AI do we want? Do we require fully autonomous drones to engage with the adversary aircraft in a dogfight or deploy autonomous patrolling vehicles at the borders for getting the job done? How much autonomy should be given to the machines on the battlefield? A clear vision of the AI programme is necessary for a middle-income country like India that cannot afford to invest heavily in this sector. It is a matter of guns vs. bread and butter — there is a trade-off between

spending in national security and public welfare. Unlike technological programmes in developed countries which can afford to fail first and fail faster, India does not have this luxury due to paucity of resources.

A clear vision of the AI programme is necessary for a middle-income country like India that cannot afford to invest heavily in this sector. It is a matter of guns vs. bread and butter — there is a trade-off between spending in national security and public welfare.

Secondly, the lack of critical infrastructure is one of the biggest impediments in the prospects of AI in India for both civilian and military uses. As AI runs complex algorithms on loads of data, it is essential to have robust hardware and enabling data banks within the country. If a critical AI-based military technology harnesses the data on a remote server located beyond the borders, it can potentially hinder the goal of Indian foreign policy from preserving its strategic autonomy in a way that it might be compromised.

Thirdly, the role of the private sector will be pivotal in making the AI accessible and efficient. As AI demands high-skills and capital, innovations need an ecosystem supporting the free flow of both money and skill. However, as per the existing FDI policy in defence, only 49% of the foreign investment is permitted within the automatic route above which it needs government approval. India has traditionally been conservative in handing over the reins of the defence industry in the hands of the private sector.

Way forward

Leading powers like the US, China and the EU (and France) have their vision documents for research and development programmes in artificial intelligence. To begin with, India should envisage a clear strategic vision regarding the AI on similar lines. Despite resource limitations, India is home to world class academicians in computer science and engineering spread across the IITs, IISc, NITs and IISERs. An academia-industry-policy synergy is of utmost importance to realise the strategic, societal and cultural implications of AI in defence. It will help us to find answers to questions raised in the previous section.

The government should create a supportive ecosystem in which the AI industry in India can thrive. There is a dire need to invest in critical infrastructure so that the data servers lie within the territory. Apart from ensuring strategic independence, it will also address data privacy concerns.

Despite resource limitations, India is home to world class academicians in computer science and engineering spread across the IITs, IISc, NITs and IISERs. An academia-industry-policy synergy is of utmost importance to realise the strategic, societal and cultural implications of AI in defence.

The AI-market for civilian purposes in the country is on the rise. For instance, India ranks third in G20 countries in AI-based startups. Last month, PM Modi unveiled his "5-I" vision to maximise the societal benefit at the G20 summit on digital economy and artificial intelligence. India should realise the dual-use nature of artificial intelligence and thus also open its market to AI investments in defence. The 49% cap on FDI policy in defence should be revisited to account for this fact. Policymakers should brainstorm on the prospects of marrying the flagships initiatives of the current government — Make in India in Defence and Digital India — to bring a technological revolution in the defence industry.

New Delhi, whose major security priorities lie in the subcontinent, cannot ignore the progress made by China in the field of artificial intelligence. The State Council AI plan, released in June 2017, outlines China's ambitious AI policy which aims to create an AI-industry of worth 150 billion RMB that is ten-fold its 2017 figures. At the same time, India should avoid setting their benchmarks taking Chinese investments in mind. Since India is a late entrant in the field, it could capitalise on the late-movers advantage, i.e., mimicking the existing narrow-AI technologies, to fulfil its basic security needs (like border patrols and intel-gathering) rather than seeking innovation. The 'AI in defence' vision should be centered on achieving military modernisation over balance of power considerations. Hence, this is the time for New Delhi to step up in the arena of what hardliner security experts refer to as an AI arms race.

NON-LETHAL WEAPONS

At first glance, 'Non-Lethal' and 'armed forces' do not seem to go along, considering that the primary role of the military is to preserve national interests and safeguard territorial integrity, sovereignty and unity of India against external threats. However, changes in the security dynamics have embroiled the Indian Army more and more in the secondary task of providing assistance to government agencies to cope with internal threats as part of 'Aid to Civil Authority' when requisitioned for the purpose. Consequently, the Indian Army has been actively involved in counter insurgency, civic action programmes (Operation Sadbhavana), disaster management and relief operations.

Army troops on numerous occasions have had to manage crowds during conduct of cordon and search operations and also while dealing with other agitations that go beyond the capability of civil administration. In fact, of late there is a growing trend of radicals and their sympathizers exploiting civilians, especially women and children, to launch public protests against the security forces. Some of these have at times turned violent. In a number of instances even army convoys have been targeted by violent mobs. A recent incident is of an army convoy getting attacked by Tamil Tiger supporters near Coimbatore in May 2009. In another incident, anti-army demonstrations broke out in Srinagar after a 10 year old girl was killed in a road accident involving a military vehicle in the same month. The recent riots in Punjab after a preacher from

an Indian sect was killed by a rival Sikh group in Austria also brought agitating civilians and the army troops mobilized to control the situation face to face. Fortunately, it did not escalate beyond a point and lead to any unsavoury situation.

Such hostile actions if uncontrolled also have the potential of causing physical harm to the troops. Though the Indian army has, by and large, with its strict code of conduct of using minimum force, done an admirable job, its human rights record has occasionally been a subject of criticism. The response by the armed forces personnel in such situations is indeed mired by the decision dilemma of using a 'shout' (which may not be adequate) or a 'bullet' (which may be too much). This is an equation that has to be addressed very deliberately since insurgents/terrorists blow out of proportion even the minutest of perceived human rights violations by the security forces. The aforesaid discussion reveals the necessity of building an additional capability of 'Non-Lethal Weapons' (NLW) in the Army, albeit only to a limited extent. NLW can be defined as weapons explicitly designed and primarily employed to incapacitate personnel and materiel, while minimizing fatalities, permanent injury to personnel, and undesired collateral damage to property and the environment.

NLW can be categorized into two kinds: Conventional -- tear gas, plastic bullets, tasers, sprays, which to an extent are already being used by some of our paramilitary and police agencies; and Unconventional -- high-power microwaves, low energy lasers, acoustic weapons, which so far do not seem to have been utilized by the Indian security forces. In principle, the use of non-lethal weapons should devolve on the paramilitary and central police forces. However, in some complex situations, their usage even by the army can help in limiting fatalities, lessening collateral property damage, and demonstrating the ability to mete out a controlled and graduated quantum of force, particularly when employed in internal security tasks.

Many countries across the world are currently developing and implementing new non-lethal capabilities with a view that many emerging and non-traditional threats can be effectively countered with a progressive response using non lethal weapons first. Such circumstances are common place in low intensity and asymmetric conflicts as well as in peacekeeping operations. Countries like the US are also engaged in capacity building of partner nations through programmes such as 'NOLES' – Non-Lethal Weapons Executive Seminar. It is NATO policy that Non-Lethal Weapons, relevant concepts of operations, doctrine and operational requirements shall be designed to expand the range of options available to NATO Military Authorities. Further, NLW should enhance the capability of NATO forces to achieve objectives such as accomplishing military missions and tasks in situations and conditions where the use of lethal force, although not prohibited, may not be necessary or desired; discourage, delay, prevent or respond to hostile activities; limit or control escalation; improve force protection; repel or temporarily incapacitate personnel; disable equipment or facilities. However, the spin-offs of using non-lethal weapons need to be weighed against the risks to security personnel vis-à-vis the general population.

Some situations in which select NLW can be effectively used are:

- Controlling an unruly and hostile mob.
- Capture of specific individuals amongst a crowd without endangering the lives of others.
- During Cordon and Search operations, in some circumstances use of NLW can also help in capturing terrorists alive. Such successes assist in improving Intelligence acquisition. The case of capture of a Pakistani terrorist, Kasab, alive during Mumbai terrorist attacks in November 2009 has amply showcased the importance of such achievements.
- Hostage rescue. A lot of collateral damage by the NSG could have been avoided while flushing out the terrorists from Taj Hotel post Mumbai terrorist attacks.
- Anti-hijack operations by specialized forces.
- Peacekeeping Operations. Incidences such as when a stone thrown by mob smashed the nose of a deputy commander of the Indian peacekeeping force near Kibumba in the Congo in October 2008 could have been avoided.

Overall, by bridging the gap between verbal caution and the option of using lethal force, NLW allow greater flexibility to the commander. When confronted with situations where the use of weapons may actually blemish the army's human and people centric approach NLW provide the buffer. The idea is not that the NLW should replace lethal weapons, but to integrate them in a complementary manner while conducting internal security tasks. Nuanced use of force will indeed help the Army in winning hearts and minds – a vital aspect in such tasks.

AUTONOMOUS WEAPONS SYSTEM (AWS)

Autonomous weapons function with minimal to no human intervention, selecting and engaging targets by themselves. Fully autonomous weapons do not yet exist, but an increasing number of countries are developing or deploying near-autonomous systems.

While no country has acknowledged deploying autonomous offensive weapon systems, even defensive systems will profoundly change the way nations think about wars and will directly affect a variety of areas, including trade and the balance of power. Issues related to the morality of these weapons and their status under international humanitarian law have generated a small but fierce global debate. A consensus has not yet emerged, but parties such as the United Nations (UN) special repporteur on extrajudicial executions and the state of Pakistan have already put forward arguments calling for a preemptive ban on development of such weapons.

For India, this debate should be viewed through the prism of its security needs. Autonomous weapons will augment the country's defenses and may in fact be better able than human soldiers

to achieve some strategic objectives, including checking cross-border infiltration. India should both develop autonomous weapons and engage forcefully in the process to create an international regulatory system. This section aims to outline the current status of autonomous weapons and provide a position that may best serve India's interest in the international debates on the issue.

State of Technology and Current Weapon Systems

A 2012 U.S. Department of Defense directive defined an autonomous weapon system as "a weapon system that, once activated, can select and engage targets without further intervention by a human operator. This includes human-supervised autonomous weapon systems that are designed to allow human operators to override operation of the weapon system, but can select and engage targets without further human input after activation." Autonomous weapon systems are, in effect, independent agents in any theater of war.

The near-autonomous defensive systems adopted by several countries are primarily used in a protective role to intercept incoming attacks. They defend a specific object or area; they do not actively seek out targets but instead respond to predetermined threats. Offensive weapon systems, in contrast, do not defend an object or target and can be deployed and used anywhere. The difference between offensive and defensive weapons is not watertight and significant overlaps can exist.

The most well-known autonomous defensive weaponry are missile defense systems, such as the Iron Dome of Israel, though they also include last line of defense weaponry such as the Phalanx Close-In Weapon System used by the U.S. Navy. Fire-and-forget systems, such as the Brimstone missile system of the United Kingdom and the Harpy Air Defense Suppression System of Israel, are also near-autonomous, given that human intervention is restricted to the initial stage of firing. South Korea uses the SGR-1—a sentry robot with an automatic mode—in the Demilitarized Zone. While this system counts as defensive because it is stationary, it would not require a major technological leap to introduce offensive capabilities by making it mobile. This added dimension would allow the SGR-1 to hunt for targets.

Apart from these examples, a number of potentially autonomous systems will be deployed in the near future. The most conspicuous is Norway's Joint Strike Missile, a sea- and ground-strike weapon, which can "hunt, recognize and detect a target [ship or land-based object] without human intervention," the New York Times reported. This could be the first near-autonomous offensive weapon to be deployed.

The U.S. Air Force holds that greater levels of autonomy are desirable. It has stated, "The vision is for a [U.S. Air Force] positioned to harness increasingly automated, modular, and sustainable [unmanned aircraft systems] resulting in leaner, more adaptable and tailorable forces that

maximize the effectiveness of 21st Century airpower." (Emphasis added.) The march toward greater autonomy therefore seems to be irreversible.

The Legal Debate

The possibility of fully autonomous offensive weapons raises contentious questions about the legality of these systems, particularly those that can target and kill humans. (Near-autonomous weapons that target objects, such as missiles or ships, are less controversial.) The question of legality is especially important given that the deployment of autonomous weapons will fundamentally affect the way wars are fought. At the heart of this debate is concern about whether these weapons as independent actors can adhere to the laws that govern modern conflicts.

The legal debate over lethal autonomous weapons revolves around three fundamental points: international humanitarian law's rules of legal review, distinction, and proportionality. Whereas legal review addresses weapon development, distinction and proportionality determine the legality of weapon deployment. The legality of deployment is questioned only after a weapon system is developed and its effects and uses tested.

The most oft-quoted provision of international law in this context is Article 36 of the first additional protocol to the Geneva Conventions, which provides a framework for the legal review of new weapons. Two imperatives determine the basic lawfulness of a weapon system: the rule against inherently indiscriminate weapons—that is, weapons whose effects cannot be limited—and the rule against weapons that cause unnecessary pain or suffering.

The laws of war related to distinction and proportionality determine the legality of using a weapon system. The principle of distinction requires parties to an armed conflict to distinguish civilian populations and assets from military assets, and to target only the latter. The law of proportionality requires parties to a conflict to determine the civilian cost of achieving a particular military target and prohibits an attack if the civilian harm exceeds the military advantage of the attack. It has also been argued that a clause in the first protocol, known as the Martens Clause, that requires weapon systems and their usage to meet the "dictates of public conscience" would control the development and deployment of autonomous weapon systems.

Human Rights Watch and the UN special rapporteur on extrajudicial executions have argued that autonomous weapon systems would be prima facieillegal as they would never be able to meet the requirements of the laws of war in any substantial manner, given that adherence to these laws requires a subjective undertaking of which machines are inherently incapable. Preprogrammed autonomous systems, the ICRC and others have argued, would never be able to assess each individual combat situation on its own merits and decide on a course of action accordingly. They would, the argument goes, engage in warfare using only objective standards for any given

situation as opposed to the subjective responses that are necessary to make war humane. Although advances in artificial intelligence might lead to weapon systems capable of such a subjective undertaking, making them truly independent in nature, these parties have argued that the development of such weapons should be illegal.

Some commentators, however, have argued that autonomy alone does not render such weapons illegal. They have insisted that in some circumstances, autonomous weapons might be better able to adhere to norms of international law. Other scholars have correctly pointed out that autonomous weapons, in any capacity, would have a wide range of uses in scenarios where civilian loss would be minimal to nonexistent, such as naval warfare. Further, because such weapon systems would not be driven by human fears, they might be able to better differentiate between combatants and civilians by waiting until physically fired upon to respond. These commentators have argued that the question of legality depends on how these weapons are used, not their development or existence.

Other analysts have contended that it is too early to argue over the legal issues surrounding autonomous weapons because the technology itself has not been completely developed yet. The debate is nascent and ongoing, primarily under the framework of the Convention on Certain Conventional Weapons (CCW).

Should Autonomous Weapons Be Banned?

Related to the question of autonomous weapons' legality is the question of how, if at all, they should be regulated.

Entities such as Human Rights Watch and the UN special rapporteur on extrajudicial executions, as well as countries like Pakistan, have called for a preemptive ban on the development and use of autonomous weapons, citing the Ottawa Treaty as a precedent. Leading academics and artificial intelligence researchers such as Stephen Hawking and Elon Musk have called for a moratorium on the development of autonomous weapons, stating that these weapons "will become the Kalashnikovs of tomorrow." These critics have argued that because it is impossible to accurately predict how an autonomous weapon may respond in a given scenario and because the easy availability of autonomous weapons may increase the likelihood of armed conflict, it is safer to ban development from the outset.

Other countries, such as the United Kingdom and the United States, have agreed that regulation may be needed but do not support an outright ban, given the benefits in reducing casualties and increasing efficiency highlighted by some commentators.

Some scholars have noted that a ban may be pointless considering that much of the automation may be incremental and targeted at outcomes such as efficiency rather than advancing lethality.

Any ban, in order to be truly effective, would need to be supported and upheld by all the major powers. This seems highly unlikely as of 2016, given that several countries have already started developing some form of autonomous weapon systems. The precedent often cited by advocates of a preemptive ban, the Ottawa Treaty, also shows the limitations of such a ban. Several major powers, including China, India, Russia, and the United States, are nonparties to the treaty, diminishing its effect.

Another issue with a preemptive ban is that the full scope of weapon automation is not yet apparent. Without knowing in what way automation could proceed, a preemptive ban would need to be so broadly worded as to put on hold all research related to any form of automation in the defense sphere. This would be akin to halting vital technological progress for militaries, an act that would be not only illogical but also highly ineffective because few militaries would subscribe to such an all-encompassing prohibition.

A significant issue regarding the regulation of such weapons is the accountability gap in case of a wrongful death of a civilian or the commission of war crimes. Ordinarily, human soldiers or their commanding officers are held directly responsible. But how would liability be assigned to a machine? And if not the machine, who ultimately is to be held responsible?

These questions do not have easy answers, and some have used this accountability gap to advocate for a preemptive ban. Others have argued for holding the developers of such systems liable. A few commentators have even stated that the current laws of war and principles of international humanitarian law are enough to bridge this gap. The debates on this issue have just started, but what is certain is that any proposed regulation would need to provide some answer to the question of liability if it is to be truly effective.

Because autonomous weapon technologies are still in an early stage of development, it is reasonable to argue that banning them is premature. Reviewing their legality from the outset under Article 36 and regulating their use would be more practical. Such regulation could be comprehensive and lay down international principles that would apply at each stage of development, testing, and deployment of autonomous weapons. In order to be truly effective, it would also need to address liability standards and proliferation.

An all-encompassing regulation or set of regulations would be far more effective than an outright ban in controlling the development and use of autonomous weapons. This is because it would have the support of a greater number of countries. Autonomous weapons do offer a number of military advantages that countries would be reluctant to let go of altogether, and as the example of the Ottawa Treaty shows, an outright ban might not have the support of the major powers, rendering it ineffective.

India's Position on Autonomous Weapons in the Global Context

While the global debate on autonomous weapons has only just begun, a number of countries have already put forward their respective positions on such systems. These positions, however, differ widely. Comparing India's stance to these countries is necessary to understand how the global debate may be shaped going forward and where India stands vis-à-vis other major powers. This review of countries' positions is restricted to the five permanent members of the UN Security Council plus India and Pakistan. Only the United States and the United Kingdom have released official documents that clearly lay down their respective positions on autonomous weapons. The other countries expressed their positions at the three gatherings of the CCW's Meeting of Experts on Lethal Autonomous Weapons Systems (LAWS) held in Geneva. The latest meeting took place from April 11 to 15, 2016, and the primary issues debated were whether a preemptive ban is justified and what should be the way forward for autonomous weapons in the international arena.

India has said that there is a need for "increased systemic controls on international armed conflict in a manner that does not widen the technology gap amongst states or encourage the increased resort to military force in the expectation of lesser casualties or that use of force can be shielded from the dictates of public conscience." It has also highlighted the issue of international security in case of proliferation of such weapon systems, arguably to nonstate actors. India has noted that there continue to be "wide divergences" on the key issues of definition and "mapping autonomy" and that there is a need to resolve these issues for any substantial framework to evolve. It has emphasized the fact that such technology has both peaceful and military uses, and that the CCW remains the "relevant and acceptable framework" for addressing any issues of concern.

China has no explicit policy or stance on autonomous weapons. In CCW meetings in 2013 and 2014, it called for further studies and discussions to understand the various issues related to autonomous weapons and to forge a consensus on them.

France categorically stated in 2013 that it "does not possess and does not intend to acquire robotized weapons systems able to open fire…independently" and that the "role of human beings in the decision to open fire must be preserved." In the 2016 Meeting of Experts, the country reiterated its position: "France would not envisage developing or employing lethal autonomous weapons systems (LAWS) unless these systems demonstrated their full compliance with international law." However, France also issued the following statement: "The fact…that a machine…carries out an attack does not necessarily entail a violation of international humanitarian law." At the annual meeting on the CCW in November 2014, France stated that the priority should be to develop a common basis before deciding the direction in which any CCW role in the regulation of autonomous weapons should be taken.

Pakistan has categorically called for a preemptive ban on autonomous weapons, stating that "LAWS are by nature unethical," and irrespective of the degree of sophistication, they "cannot

be programmed to comply with International Humanitarian Law." It has stated that autonomous weapons will "lower the threshold of going to war" and create an accountability vacuum. Such weapon systems, in Pakistan's opinion, would deprive combatants of the protection of international law and would also greatly risk the lives of civilians and noncombatants. Pakistan has argued for a legally binding CCW protocol that preemptively bans the development and use of such weapons.

Russia has no explicit stance on autonomous weapons but has stated that serious attention must be paid to the implications that the use of such weapons could have for societies.

The United Kingdom's Ministry of Defense issued a Joint Doctrine Note in 2011, stating that the ministry has "no intention to develop systems that operate without human intervention…but it is looking to increase levels of automation where this will make systems more effective." The UK stated in 2016 that it believes "LAWS do not, and may never, exist." It further noted that the debate over autonomous weapons is essentially a debate on the "means and methods of warfare" and that, therefore, current international humanitarian law is enough to regulate the use of any new weapon systems. The UK categorically believes that existing weapon systems do not fall under the term "lethal autonomous weapon systems."

The U.S. Department of Defense issued a directive in 2012 on the use of autonomous weapons, which called for "appropriate levels of human judgment over the use of force." The United States stated in 2014 that the current scenario is too "premature" to decide where any discussions on autonomous weapons will lead. It clarified two years later that any discussion on autonomous weapons will necessarily need to examine emerging technologies and would not cover existing weapon systems. While the United States has agreed that "lethal autonomous weapons may present important legal, policy and ethical issues," it has not advocated an outright ban on such weapon systems. Instead, it has described "a non-legally binding outcome document that describes a comprehensive weapons review process" that would "help ensure consistency and quality in the weapons review process by all States."

A Way Forward for India

Disarmament rather than arms control has been the primary framework for India's approach to the international regulation of weapon systems. The country has also opposed inequity and discrimination in the structuring of arms control treaties. Its refusal to sign the Nuclear Non-Proliferation Treaty and the Comprehensive Nuclear-Test-Ban Treaty reflects these considerations. Since the 1990s, though, India has moved toward an emphasis on national security considerations and has been willing to support pragmatic arms control measures as part of its new self-perception as a responsible power.

The issue of autonomous weapons in India is likely to be driven by the country's unique security situation, which features two hostile neighbors and the ever-present threat of insurgency. This position gives Indian military preparedness a very defensive tint wherein the singular objective is to defend Indian borders and assets with minimal loss of lives.

Autonomous weapons could provide the twin benefits of reducing military casualties and improving efficiency in defensive capabilities. Their single-biggest benefit could be that they are not governed by human emotions, making it possible to deploy them 24-7, three hundred sixty-five days a year in any weather or geographical condition. They could carry out several functions with minimal to no military casualties. This would have a tangible impact in areas such as the Siachen Glacier in the high Himalayas, on the border with Pakistan, where India has lost 883 soldiers since 1984, all to the harsh weather.

In 2014, India recorded more than 175 infiltration attempts across the Line of Control, the effective military boundary between India and Pakistan, and it is quite possible that a number of attempts went unnoticed. The perpetrators of the January 2016 attack on the Pathankot Air Force Station in all probability slipped across the international border from Pakistan.

Given the harsh geography of the Line of Control and the international border, autonomous weapon systems such as the SGR-1 or a similar system would likely be better able to check infiltration attempts than routine manned patrols. Additionally, an autonomous system would probably be better able to guard and defend the Line of Actual Control with China, much of which passes through sparse, uninhabited mountainous regions, where manned patrols have been ineffective.

Another factor that could tilt the balance in favor of India's development of autonomous weapons is the country's need to protect its considerable and growing space assets; autonomous systems could meet this need in a far more efficient manner than any manned system. P. W. Singer, a senior fellow at New America, has pointed out that the use of autonomous weapon systems could play a pivotal role in the protection of space assets and in any potential space conflicts. This could become important especially in light of the much-publicized Chinese capability to destroy satellites in orbit. A defense system that could automatically detect incoming threats to satellites and launch missiles to intercept them in seconds would be necessary to counter such a capability.

Further, given that China is possibly developing autonomous weapons of its own, it may become necessary for India to develop such systems. And while Pakistan has categorically called for a ban on developing autonomous weapons, this should not be taken at face value. In the past, for example, Pakistan has called for a nuclear-free South Asia while simultaneously developing nuclear capabilities.

Any significant deployment of autonomous weapons along international borders, however, would raise a number of issues, most importantly, liability in the case of civilian death. It would

be highly unethical to deploy such weapon systems before filling the liability gap, either by domestic means or with international regulations. Another issue could be the political fallout of deploying such systems along disputed borders. The SGR-1, for example, is stationary, and deploying it is tantamount to building permanent border infrastructure—an act that is already controversial along disputed borders, such as the one between India and China. Deploying this sort of weapon along the India-China border or the Line of Control could ratchet up long-simmering tensions. And if India were to deploy autonomous weapons in these areas, it must be ready to accept that similar actions could be taken by China, Pakistan, or both.

There is also the specific issue of India's indigenous development. A vast technological gap exists between arms-exporting and arms-importing countries, and India is currently dependent on arms imports. This negatively affects both national security and the trade balance. Because of this, India has woken up to the need to develop such weapon systems indigenously. This development would have a twofold effect. First, it would decrease India's dependence on importing critical weapon technologies, which is necessary to shore up its defense security. Second, it would augment high-tech research and development as well as manufacturing in India. The latter development will benefit the country in the long run by turning the tables of trade and possibly making it an arms exporter.

Development, however, need not automatically lead to deployment; India could refrain from using autonomous weapon systems while simultaneously exporting them. Deployment and export would be governed by different rules, and one is not necessarily tied to the other.

India's defense establishment seems to have recognized these issues. The Defense Research and Development Organization (DRDO) confirmed in 2013 that the country is developing "robotic soldiers" with a "very high level of intelligence to enable them to differentiate between a threat and a friend," to be deployed in areas such as the Line of Control. It asserted that "a number of labs are already working in a big way" on such systems. The descriptions of these systems nearly match that of a fully autonomous weapon system, and may be the clearest indication from any country that such weaponry is under development. The then chairman of the DRDO stated that same year that these autonomous systems would be ready for deployment around 2023. However, because the DRDO has historically overshot its delivery dates and is prone to exaggeration, these statements must be taken with a grain of salt and considered an expression of intent rather than as the final word on delivery timelines.

While it remains to be seen if India will deploy autonomous weapon systems by 2023, it has already started acquiring and deploying near-autonomous weapon systems such as the Harpy Air Defense Suppression System and the Phalanx Close-In Weapon System. It is also possible that India will gradually move toward greater automation of missile defense shields including the Prithvi Air Defense and the Advanced Air Defense. These systems target objects and not humans per se, and the acquisition of one need not necessarily mean the development or deployment of the other. However, this highlights the fact that India is readily adopting weapon systems with

ever-greater levels of autonomy and may not, therefore, shy away from developing or adopting an autonomous weapon system that targets humans.

As India steps up the effort to develop autonomous weapons and considers their deployment, New Delhi is bound to confront the question of their legality. India is not party to either the Ottawa Treaty or the first additional protocol to the Geneva Conventions. It is therefore highly unlikely that it will sign on to an international treaty that seeks to ban the development of autonomous weapon systems. Further, few states follow the requirements of Article 36 of the first additional protocol, parties to the convention or otherwise. It would therefore be difficult to argue that this provision has become part of customary international law binding India. At any rate, it remains to be seen how individual reviews as envisioned in Article 36 will work in practice.

India could develop a domestic legal regime that fixes liability for the actions of these weapons and lays down rules of engagement and conditions for export. While the international debate is still raging, there is no reason why India cannot move forward with establishing a domestic regime, especially given the DRDO's express intentions to develop such weapons. Such a move would help India take a leadership position in the international debates surrounding autonomous weapons.

From India's perspective, a ban would be highly impractical, given the country's security considerations and the fact that it has already started developing such systems. India would argue that autonomous weapon systems are not illegal by the mere fact of their being autonomous. Further, given the issue of a possible technology gap emerging between nations, which India has highlighted at CCW discussions, it is in India's interest to argue for regulation of autonomous weapons, within the CCW framework, as opposed to a preemptive ban.

International regulation becomes especially necessary with the possibility that such weapon systems will spread to nonstate actors. The numerous insurgencies that India faces make it especially vulnerable in such a situation. The benefits that autonomous weapon systems bring to conventional forces would extend to any party in possession of such systems. Further, given that such weaponry, though high-tech, can easily be duplicated makes its proliferation more probable.

The proliferation of weapon systems has remained a major concern for India, evidenced by the country's statement at the United Nations General Assembly session on the Arms Trade Treaty. While explaining its decision to abstain from voting on the treaty, India stated that "such a treaty should make a real impact on illicit trafficking in conventional arms and their illicit use especially by terrorists and other unauthorized and unlawful non-state actors." The decision to abstain was based on the fact that terrorism and nonstate actors were not mentioned in the specific list of prohibitions in the draft text of the treaty.

Appropriate regulation of not only the development of such systems but also their trade would certainly address India's concerns on this score. Regulations would also need to focus on the

conditions of use, export, and sale restrictions, as well as on liability in case of proliferation, illegal use, and accidents caused by malfunction of the systems. At the same time, New Delhi would want to make sure that India is not on the receiving end of any restrictions on trade in autonomous weapons and the transfer of advanced technologies. Its entry into the various export control groups would diminish such a prospect and reinforce its claim to a seat at the table for the global management of new weapon systems.

Conclusion

The legal and ethical questions that surround autonomous weapons are still a long way from answered. But politically and militarily, India must recognize the various benefits that autonomous weapon systems can bring, especially given the country's unique security situation. India should not shy away from developing systems, as its defense establishment has acknowledged. And around the world, while there is no doubt that the development and deployment of autonomous weapons have raised and will continue to raise important legal and ethical questions, the march toward some form of automation is likely to continue. A ban at this stage, where the full scope of such weapon systems is still unknown, would be jumping the gun.

At the same time, as an emerging power, India must actively join and contribute to the international debate on autonomous weapons. It must focus on promoting a pragmatic international regulatory mechanism on the development, use, and trade of autonomous weapon systems. As one of the few countries more or less openly developing this weaponry, India has a unique opportunity to assume leadership in this domain. The military benefits potentially provided by such systems, especially in terms of effectiveness and possible lives saved, mean it is in the country's interest to develop and deploy them. However, the potential damage that can be caused by the misuse of these technologies, especially by nonstate actors, also means it is in India's interest to ensure that any future international regulation prevents the abuse of new military technologies.

Given the nascent stage of the international debates, it is possible that autonomous weapons may be developed and deployed before any substantial international regulation is put in place. India can make use of this opportunity to set global standards by adopting a domestic regulatory framework that deals with all aspects of such weapon systems. As India is a major military power, any step taken by the country will be closely followed, and leading on this issue would allow India to set the global agenda on its terms.

MODULE-II

Defence Technology and Defence Law

BACKGROUND TO DEFENCE TECHNOLOGY AND POLICY

Law & Technology

Technology is a distinct characteristic of the 21st century. Technology forms an instrumental part of the way the world works today. Ever since its inception, it has been heedfully received by the masses, revolutionizing and decentralizing the way world functions. New technologies are emerging at pace so fast that these technologies are surpassing its predecessors. It has seeped into governance, administration, management, security & defence, education, trade & commerce, science & medicine, research & development etc.

The number of international actors participating in technological developments has also expanded and the relative weight of governments, private sector and institutions in Research and Development (R&D) has begun to shift. Importantly, a number of developing countries are leveraging technology, especially digital technologies, to accelerate economic development. It's escalation onto several arenas of the modern life has called for State intervention, regulation and control. Tech developers, despite their superior knowledge on technology, cannot and should not be allowed to exercise supremacy. Technology is characterized by persistent fast-pace development and change, making it difficult for lawmakers to understand it's nitty-gritty's, let alone formulation of legislations to govern technology. It's not necessary for all emerging technologies to be in the interest of societal development; emerging technologies can also be against societal ethics and morality, making State intervention extremely crucial.

Technology changes at a faster pace than legislation and therefore, lawmakers lag behind state of the art when creating appropriate laws. Regulatory authorities shall take time to understand its scope, problems, potential risks and disputes as and when they arise.

Technological advancements enabled numerous businesses to grow and thrive in the marketplace. Intellectual property rights (IPR) play a crucial role in protecting new technologies and monetizing through licensing revenue streams. Intellectual property can be in the form of patents, trademarks, industrial designs, copyrights and geographical indications. Intellectual property, especially patents help in protecting an invention or new technology, thus excluding other to make, manufacture, and sell without the consent of the inventor for a specific period. Robust intellectual property law is essential to encourage innovation, research and development in technology, particularly in developing countries. It's also possible that a strong IPR enforcement can lead to monopoly pricing, particularly in developing countries that invest little in R&D and depend on foreign innovations. Lawmakers' intervention becomes crucial in such cases.

With the advent of technology, e-commerce businesses have flourished to a remarkable extent across the globe. E-commerce businesses have revolutionized the manner in which traditional businesses are conducted. Transactions over e-commerce websites require consumers to sign online contracts, popularly known as 'Terms and Conditions' or 'Terms of Usage'. Without

agreeing to the 'Terms and Conditions' of the seller, the consumer cannot go ahead with the purchase of the product/service. Lawmakers have recognized the need for separate legislations to regulate such businesses and ensure these 'terms and conditions' are within societal and governmental framework. The age of technology has also pursued lawmakers to protect cyber crime victims.

The word 'blockchain technology' has been in rounds since late 2000s and its proponents believe that it will decentralize the functioning of our economy and the manner in which we contract; how and to what extent will lawmakers intervene to regulate such technology remains a question mark.

The above examples amount to illustrate a miniscule relationship between law and technology. This paper aims to explain the importance of technology in defence and how defence technology interacts with law in its regulation and implementation in India.

Defence Technology

Protection of territorial borders and ensuring its safety and security has been significant function of the State since time immemorial. Threats from other nations and militant groups entail an efficient, effective and sound defence technology. Defence technology is the application or usage of technology in warfare; it is developed by scientists and specialists specifically for military purposes. 'Military innovations from wooden catapults to nuclear bombs have been transforming the way war is waged since prehistoric humans carved arrows from stones some 10,000 years ago.'[1] Traditionally, defence technology focused on the internal aspects of the technology - the nuts and bolts approach - weapons, accoutrements machinery, fortifications, and all the physical relics of war.[2] Defence technology went through rapid change in the 19th century, it alone being seen as having the capability to decide outcome of warfare.[3]

Importance of Defence Technology

21st century defence involves demonstration of technological strength, display of technologies via various military exercises, conducting 'tests' of new weapons/weapon delivery platforms for the purposes of the expression of the power and building up of an effective deterrence

[1] Thomas Macaulay & Tamlin Magee, The Future of Technology in Warfare: From Drones Swarms to VR Torture, Tech World, (April 18, 2018), available at https://www.techworld.com/security/future-of-technology-in-warfare-3652885/, (last visited May 22, 2019).

[2] Barton C. Hacker, Military Institutions, Weapons, and Social Change: Toward a New History of Military Technology, 3, Published by: The Johns Hopkins University Press and the Society for the History of Technology, JSTOR.

[3] Ibid.

mechanism. In short, there exists an inter-relation between security and technology. Defence technology investment enables the State to combat threats and overcome any advantages the opposition may seek. Defence technology enables policymakers to detect and prevent threats before the onset of war. Technology especially helps in countering terrorist threats, whose needs cannot be met by conventional methods, rather by intelligence methods and capabilities.

In the age of development of weapons of mass destruction and/or harmful technologies, the State must improve its military capability to prevent or combat such weapons. An efficient technological support is crucial to locate, neutralize, prevent and/or combat such weapons before their operation.

Technology enables effective operation of defence forces that outside national territory; it facilitates communication and coordination with friendly/ally forces.

An essential feature of war is to gain familiarity with unknown or overseas locations and their respective threats – to the extent of complete and real-time digital picture and digitization of these areas. The advent of technology has enabled defence forces to gain such familiarity and take necessary action. 'Satellites are found extremely important for the purposes of intelligence gathering. Particularly remote sensing satellites are significant for the purposes of reconnaissance and imagery intelligence.'[4]

Persistent research and development lays the nucleus for defence technology. Given technology's rapid changing nature, it is always subject to surprises and defence forces must be prepared to combat such surprises. Research in key technological issues may even prevent such surprises or lay the foundation for combating it in the future.

Innovations in the fields of communications and information technology enabled secure, faster and dependable basic hardware and support infrastructure; whereas innovations in the fields of composite materials and nano-technology have made the platforms lighter and stealthier. 'Particularly, the dependence of states on various technologies for war fighting could be said to have brought in the concept of Revolution in Military Affairs (RMA). This involves induction of computer networks that confer information superiority, allows precision strikes on the targets, permits dominant manoeuvre, and undertakes usage of space based assets for militaristic purposes. Basic important aspects of the RMA are the advent of trustworthy standoff weapons. Also, induction of weapons like JDAMS (Joint direct attack munitions), delivered over a target from an aircraft with the help of global navigational systems like GPS has helped the states to avoid collateral damage. Such weapons could be dropped from higher heights and under any other weather conditions. It needs to be mentioned here that the concept of RMA goes

[4] Gp Capt Ajey Lele (Retd.), Technologies and National Security, Indian Defence Review, (November 11, 2010), available at http://www.indiandefencereview.com/news/technologies-and-national-security/2/, (last visited May 22, 2019).

beyond technology. It also involves doctrine, strategy, training, administrative support, etc. But, the entire process of doctrine and strategy development would have to have the technology premise at its backdrop.'[5] RMA technologies enable precise target destruction and speedy decision making. Advanced military technologies also make these technologies affordable throughout their life cycle.[6]

India has seen a sharp rise in the volume of expenditure and investment on defence & defence technology in the last few years. It is at a constant threat from it's neighbours and fashions a strong defence mechanism. In 2018, India spent $66.5 billion on defence, ranking 5th amongst the biggest military spenders. [7] India is also one of the largest importers of arms as of 2018.[8]

Defence in India

The Ministry of Defence, which provides the policy framework and wherewithal to the Armed Forces to discharge their responsibilities, coordinates and supervises all matters and agencies relating to defence and national security. The Defence Minister is the head of the Ministry of Defence. The Ministry of Defence constitutes of four departments:

- Department of Defence (DOD)
- Defence Research and Development Organisation (DRDO)
- Department of Defence Production (DDP)
- Department of Ex-Serviceman Welfare (DESW)

'The Department of Defence is responsible for three services i.e Army, Air Force, Navy and Coast Guard. It is also responsible for the Defence Budget, establishment matters, defence policy, matters relating to Parliament, defence cooperation with foreign countries, and coordination of all defence related activities. Defence Secretary is also responsible for coordinating the activities of the other Departments i.e DDP, DESW and DRDO in Ministry of Defence.'[9]

The Defence Research and Development Organization (DRDO) is responsible for military research and development. DRDO is a network of more than 50 laboratories which are deeply

[5] Ibid.

[6] Ibid.

[7] Stockholm International Peace Research Institute , Trends in World Military Expenditure 2018, 1 , available at https://www.sipri.org/sites/default/files/2019-04/fs_1904_milex_2018.pdf, (last visited May 22, 2019).

[8] Stockholm International Peace Research Institute, Trends in International Arms Transfers 2018, 1 , available at https://www.sipri.org/sites/default/files/2019-03/fs_1903_at_2018.pdf, (last visited May 22, 2019).

[9] Introduction, Department of Defence, available at https://mod.gov.in/dod/about-department-defence-0, (last visited May 22, 2019).

engaged in developing defence technologies covering various disciplines, like aeronautics, armaments, electronics, combat vehicles, engineering systems, instrumentation, missiles, advanced computing and simulation, special materials, naval systems, life sciences, training, information systems and agriculture.[10]

The Department of Defence Production (DDP) is responsible for developing a comprehensive production infrastructure to produce the weapons, systems, platforms, equipment required for defence. The Department through its Ordnance Factories and Defence Public Sector Undertakings (DPSUs) has established wide range of production facilities for various defence equipment. A large number of major products have been developed through in-house research and development initiatives apart from producing a number of products and equipment through transfer of technology.[11]

In consideration of the expanding population of the ex-servicemen and windows, the Department of Ex-Servicemen Welfare was established to look after the welfare, resettlement and rehabilitation ex-servicemen, war widows and their dependents. [12]

Regulation of Defence Technology in India

The Ministry of Defence prepares Technology Perspective And Capability Roadmap (TPCR) in order to provide overview/guidelines on the equipment to the industry that maybe inducted into the forces. TPCR aspires to guide the technology development process in planning or initiating technological development and/or partnerships and production arrangements. The first TPCR was published in April 2013, which aimed at development and transformation of superior technology into affordable and critical military capability, considering affordability, timeliness, dual use, technology base and modular design. The Ministry of Defence has the right to update, alter, and delete any part of the TPCR. The revised second edition of the TPCR was published in 2018 with updates/changes. The TPCR also gives due importance to the government's thrust towards 'Make in India' and encourages the industry must accord to it for its plans and initiatives. [13]

The Defence Production Policy guides the industry in matters of production equipment and technology, while placing importance on self reliance. The objectives of the Policy are to achieve substantive self reliance in the design, development and production of equipment/ weapon

[10] Genesis and Growth, Defence Research & Development Organization, available at https://www.drdo.gov.in/drdo/English/index.jsp?pg=genesis.jsp, (last visited on May 22, 2019).
[11] About the Department, Department of Defence Production, available at https://ddpmod.gov.in/about-ministry, (last visited May 22, 2019).
[12] About DESW, Department of Ex-Servicemen Welfare, available at http://www.desw.gov.in/about-us/about-desw, (last visited May 22, 2019).
[13] Technology Perspective and Capability Road Map (TPCR 2018), Ministry of Defence, available at https://mod.gov.in/sites/default/files/tpcr.pdf, (last visited May 22, 2019).

systems/ platforms required for defence in as early a time frame as possible. The policy states the setting up of separate funds to provide required resources to public/private sector including small and medium sized enterprises to enhance and support the research and development of cutting edge defence technology. In matters of transfer of technology, the policy dictates the involvement of DDP, DRDO, and Integrated Defence Staff in identification and evaluation of the technology and is also responsible to ensure the absorption of the technology into the Indian industry, thereafter, successive weapon systems/platforms will be developed in the country.

The Ministry of Defence has established Defence Procurement Procedure. The preamble of this procedure commences with "Defence acquisition is not a standard open market commercial form of procurement and has certain unique features such as supplier constraints, technological complexity, foreign suppliers, high cost, foreign exchange implications and geo-political ramifications. While maintaining highest standards of transparency, probity and public accountability, a balance between competing requirements such as expeditious procurement, high quality standards and appropriate costs needs to be established. As a result, decision making pertaining to defence procurement remains unique and complex".[14] 'The aim of the procedure is to ensure timely procurement of military equipment, systems and platforms as required by the Armed Forces in terms of performance capabilities and quality standards, through optimum utilisation of allocated budgetary resources; while enabling the same, the procedure will provide for the highest degree of probity, public accountability, transparency, fair competition and level-playing field. In addition, self-reliance in defence equipment production and acquisition will be steadfastly pursued as a key aim of the Defence Procurement Procedure.'[15] The procedure has been set forth for the procurement of capital equipment, except for medical equipment.

The Defence Procurement Manual incorporates all rules, guidelines and processes to be followed for the procurement of goods and services to enable labs and establishments in the development of weapons and systems, incorporating technologies with the aim of self-reliance, probity and transparency within the framework of Government rules. The manual aims optimal utilization of the DRDO budget by meeting quality and uniformity standards.[16]

In addition to this, the an Intellectual Property Law (IPR) policy has been incorporated for the purpose of Defence. This IPR Policy will be applicable to software products developed by Defence Services jointly with a Developer(s). This policy will provide guidelines as to the ownership of intellectual property rights of software/computer program. The software or computer program created by the Developer could be delivered either as a hardware, a part of a hardware or on any independently readable medium. The government must have joint ownership over intellectual property rights developed by the Developer that is 'worldwide, perpetual,

[14] Defence Procurement Procedure, Ministry of Defence, available at https://mod.gov.in/sites/default/files/Update060519_0.pdf, (last visited May 22, 2019).
[15] Ibid.
[16] Procurement Manual 2016, Defence Research and Development Organization, available at https://www.drdo.gov.in/drdo/English/procurement-manual-2016.pdf, (last visited May 22, 2019).

unlimited, nonexclusive, irrevocable and royalty-free license to use, modify, make derivative work, translate, adapt, improve, merge with other computer programs or software, reproduce, disseminate, reverse engineer, release or disclose computer programs or computer software in whole or in part, in any manner, and for any purposes whatsoever, and to have or authorize others to do so.'[17] 'The above shall ensure that Government is able to exercise its ownership rights to develop and produce such technologies including computer programs and computer software, generated during the Project, to the fullest extent for the Government purposes including defence applications, free of any charge as well as free from any legal or other encumbrances/ hurdles.'[18] The Developer has the propriety rights over the software/computer program and the government must have full rights over such software/computer programme without which the usage of software/computer program will not be possible.

India follows a 'No-first use' doctrine in matters of usage of nuclear weapons. This doctrine dictates that nuclear weapons will only be used in retaliation against a nuclear attack on Indian Territory or on Indian forces anywhere.[19]

India makes treaties/contracts with other countries for transfer of defence equipment and technology which in itself governs the regulation of defence technology.

TECHNOLOGY DIFFUSION

Technology diffusion or diffusion of innovations is a theory that seeks to understand reasons, methods and the rate at which technologies/innovations spread in a social system. The theory of diffusion of innovations originated in the first half of the 20th century and was later popularized by American sociologist Everett M. Rogers in his book Diffusion of Innovations, first published in 1962.[20] 'The pattern of worldwide technical change is thus determined in large part by international technology diffusion.'[21] Some of the major channels that facilitate technology diffusion are international trade and foreign direct investment. The need for export controls is greater than ever before to prevent destructive or dangerous technologies passing on dangerous to actors, however, some diffusion of defence technology becomes inevitable and shall gradually increase parallel to the evolution of technology. Considerable amount of development in defence technology can also be attributed to innovation in civilian technology.

[17] Defence IPR Policy for Jointly Developed Software, Ministry of Defence, available at https://mod.gov.in/sites/default/files/defiprp.pdf, (last visited May 22, 2019).
[18] Ibid.
[19] The Cabinet Committee on Security Reviews Rationalization of India's Nuclear Doctrine, Ministry of External Affairs, available at https://mea.gov.in/press-releases.htm?dtl/20131/the+cabinet+committee+on+security+reviews+perationalization+of+indias+nuclear+doctrine, (last visited May 22, 2019).
[20] Rima E. Rudd, Vanessa Watts Simonds, Diffusion of innovations, Britannica, available at https://www.britannica.com/topic/diffusion-of-innovations, (last visited on May 24, 2019).
[21] Wolfgang Keller, International Technology Diffusion, 752, Journal of Economic Literature, (September 2004).

'Dual-use technology is often regarded as civilian technology that could also be diverted for military applications.[22] Control or denial of technology to potential technology developers will be difficult considering the greater role of market forces, commercial value of such technologies and decline in influence of government on technology transfers.[23] Major technology transactions happen between multinational companies spread across the world. As Technological sophistication and the cost of development rise sharply, industries depend heavily on export markets and the buyer is no longer satisfied with the product alone and some form of technology transfer connected to the manufacturing or production processes is almost invariably part of the contract.[24] The world today is more interactive and interdependent because of technology diffusion; it has facilitated the need for cooperation to maintain international peace and security. However, increased information may feed suspicions and threats. Technology diffusion in defence has expanded the scope of the battlefield – from traditional 'front-line' battle to technology capabilities that allow military forces to know the nook and cranny of enemy territory.[25] However, such technological sophistication has also made additional parties vulnerable to such weapons, especially in the light of development of 'weapons of mass destruction'; there is a critical need for intervention of international communities.[26] It is unclear how or to what extent individual nations will adopt to the technological changes worldwide; it is however clear that there will be intense pursuit of technology due to increased/new level of awareness of established technologies.[27] An agreement for harmonious conduct of international affairs for peace and stability will instigate broader distribution of technologies.

PROLIFERATION AND DISARMAMENT

Sophistication of technologies paved way for weapons of mass destruction. These weapons are capable of causing dangerous, devastating and long lasting effects, often causing more deaths than intended. These weapons have social, economic and political implications and therefore, forces political institutions to regulate the usage of these weapons for peace, security and stability. The aftermath caused by such weapons have radicalized traditional patterns of international relations. Proliferation refers to the increased capability of different nations to possess and/or use weapons of mass destruction. A nation's capability to produce such weapons creates a chain of proliferation – it encourages other nations to do the same; and this shall have devastating consequences if those nations dispute over international relations. Intergovernmental conversations may at least curb usage of such weapons in warfare; unfortunately, the same

[22] Amitav Mallik, Technology and Security in the 21st century A Demand-Side Perspective, 5, (Stockoholom international Peace Research Institute), (Oxford University Press, 2004).
[23] Ibid.
[24] Ibid.
[25] Ibid.
[26] Ibid.
[27] Ibid.

cannot be said for non-governmental institutions such as terrorist groups, who may use these weapons to accomplish violent objectives.

The proliferation of mass destructive weapons necessitates disarmament – which means the reduction or prohibition in the development, production, acquisition, usage or transfer of such weapons.

Chemical

'A chemical weapon is any toxic chemical that can cause death, injury, incapacitation, and sensory irritation, deployed via a delivery system, such as an artillery shell, rocket, or ballistic missile.'[28] Chemical weapons are capable of inhibiting respiratory and cardiovascular functions that severely affect the body's basic functioning and may even cause death. Although chemical weapons were in use much before 1675, when France and Germany agreed to limited usage of chemical weapons[29], modern chemical warfare can be traced to World War I.[30] German army released 168 tonnes of chlorine poisonous gas onto the Ypres, Belgium towards French and Algerian forces, instantly killing 5000 and injuring another 10,000. By the end of the First World War, chemical weapons killed 100,000 people and injuring an estimated one million.[31] Cold War period witnessed significant chemical weapons manufacture. By the 80s, an estimated 25 states had chemical weapon capabilities.[32]

The Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on their Destruction in short Chemical Weapons Convention (CWC), 1992, aims to eliminate chemical weapons by prohibiting the production, development, acquisition, retention, transfer or use of chemicals by State parties. State Parties are responsible to enforce the prohibition of the stated practices within their jurisdiction. [33] Organization on the Prohibition of Chemical Weapons (OPCW) was set up for the practical enforceability of the CWC. India is also a State Party to the CWC, as a result of which, it has passed The Chemical

[28] Chemical Weapons: Frequently Asked Questions, Arms Control Association, available at https://www.armscontrol.org/factsheets/Chemical-Weapons-Frequently-Asked-Questions, (last visited May 28, 2019).
[29] Origins of the Chemical Weapons Convention and the OPCW, Organization for The Prohibition of Chemical Weapons, available at https://www.opcw.org/sites/default/files/documents/Fact_Sheets/English/Fact_Sheet_1_-_History.pdf, (last visited May 28, 2019).
[30] Ibid.
[31] David Hughes, Chemical weapons: The day the first poison attack changed the face of warfare forever, (April 28, 2016), available at https://www.independent.co.uk/news/world/politics/chemical-weapons-warfare-remembrance-day-poison-mustard-gas-first-world-war-ypres-isis-a7005416.html, (last visited May 28, 2019).
[32] Chemical Weapons, United Nations Office for Disarmament Affairs, available at https://www.un.org/disarmament/wmd/chemical/, (last visited April 28, 2019).
[33] Chemical Weapons Convention, OPCW, available at https://www.opcw.org/chemical-weapons-convention, (last visited May 28, 2019).

Weapons Convention Act, 2000, to give effect to the CWC and has set up National Authority Chemical Weapons (NACW) to implement the provisions of the Convention.[34]

Nuclear

The USA atomic bombings of Hiroshima and Nagasaki, Japan on the 6th and 9th of August, 1945 ended World War II and had begun the atomic era. These two bombings are the only instances of nuclear bombings in the history of warfare. The bombs had devastating effects – it had an explosive yield of 15000 tonnes of TNT (unit of energy), wrecked more than 70% buildings and caused approximately 80,000 deaths instantly and 140,000 deaths by the end of 1945, caused severe burns, chronic diseases and cancer among the survivors. The death toll rose to 200,000 in subsequent decades.[35] Nuclear weapons are said to be the most destructive, indiscriminate and inhumane weapons ever created. Unlike other weapons, apart from instant large scale devastation, they're uniquely persistent, spread and genetically damaging radioactive fallout.[36]

USA was the first country to possess nuclear weapons and therefore enjoyed monopoly over them immediately after the Second World War, which also empowered it to dominate international relations.[37] After USA, nuclear proliferation spread to Soviet Union, Great Britain, France, China, India and Pakistan and many other nations have the resources to develop nuclear weapons or they may do so in the future.[38]

Treaty on the Non-Proliferation of Nuclear Weapons (NPT), 1968, is a landmark international treaty whose objective is to prevent the spread of nuclear weapons and weapons technology, to promote cooperation in the peaceful uses of nuclear energy and to further the goal of achieving nuclear disarmament and general and complete disarmament.[39] India refused to accede to the NPT and maintains a clear stance it shall never do so.[40] In 2008, India and USA entered into civil nuclear agreement. 'The core of this agreement, in the area of nuclear energy, was the emphasis

[34] §6, The Chemical Weapons Convention Act, 2000.

[35] Hiroshima and Nagasaki bombings, International Campaign to Abolish Nuclear Weapons, available at http://www.icanw.org/the-facts/catastrophic-harm/hiroshima-and-nagasaki-bombings/, (last visited May 28, 2019).
[36] Catastrophic harm, International Campaign to Abolish Nuclear Weapons, http://www.icanw.org/the-facts/catastrophic-harm/, (last visited May 28, 2019).
[37] Vinay Kumar Malhotra, International Relations, 337, (3rd ed., Anmol Publications Pvt. Ltd., New Delhi).
[38] Vinay Kumar Malhotra, International Relations, 338, (3rd ed., Anmol Publications Pvt. Ltd., New Delhi).
[39] Treaty on the Non-Proliferation of Nuclear Weapons (NPT), United Nations Office for Disarmament Affairs, available at https://www.un.org/disarmament/wmd/nuclear/npt/, (last visited May 28, 2019).
[40] Kallol Bhattacharjee, India will never sign NPT, says Sushma Swaeaj, The Hindu, (July 21, 2016), available at https://www.thehindu.com/news/national/India-will-never-sign-NPT-says-Sushma-Swaraj/article14499613.ece, (last visited May 29, 2019).

on non-proliferation of Weapons of Mass Destruction (WMD).Even though India did not officially join the Non-Proliferation Treaty (NPT), through this agreement it was afforded the same benefits and advantages as other leading nuclear powers, like the United States.'[41] The Nuclear Suppliers Group (NSG), formed in 1974, is a group of nuclear supplier countries that seeks to contribute to the non-proliferation of nuclear weapons through the implementation of two sets of Guidelines for nuclear exports and nuclear-related exports.[42] It is consistent with NPT. India seeks membership into the NSG but had received strong oppositions from China because it has not signed the NPT.[43]

India follows a 'No-first use' doctrine in matters of usage of nuclear weapons. This doctrine dictates that nuclear weapons will only be used in retaliation against a nuclear attack on Indian Territory or on Indian forces anywhere.[44]

Biological

Biological weapons involve the use of toxins or infectious agents that are of biological nature.[45] It includes bacteria, viruses or fungi. These agents disenable or kill humans, animals or plants for warfare.[46] Biological weapons were is use since the dawn of civilization; modern usage of biological warfare can be traced to the Second World War. Germany, America and Britain possessed biological war capabilities but abstained from their usage. Japan, however, used biological weapons on China. 'The Japanese army poisoned more than 1,000 water wells in Chinese villages to study cholera and typhus outbreaks. Japanese planes dropped plague-infested fleas over Chinese cities or distributed them by means of saboteurs in rice fields and along roads.

[41] FP Staff, India-US Nuclear Deal: All you need to know about the landmark agreement, (July 31, 2017), available at https://www.firstpost.com/india/india-us-nuclear-deal-all-you-need-to-know-about-the-landmark-agreement-3596209.html, (last visited May 29, 2019).
[42] About the NSG, Nuclear Suppliers Group, available at http://www.nuclearsuppliersgroup.org/en/about-nsg, (last visited May 29, 2019).
[43] NDT Special Bureau, India Will Become NSG member: Sooner than Later, New Delhi Times, (May 6, 2019), available at https://www.newdelhitimes.com/india-will-become-nsg-member-sooner-than-later/, (last visited May 29, 2019) .
[44] The Cabinet Committee on Security Reviews Rationalization of India's Nuclear Doctrine, Ministry of External Affairs, available at https://mea.gov.in/press-releases.htm?dtl/20131/the+cabinet+committee+on+security+reviews+perationalization+of+indias+nuclear+doctrine, (last visited May 29, 2019).
[45] Jasmine Collier, Bioterrorism: Should we be worried?, Medial News Today, (February 28, 2018), https://www.medicalnewstoday.com/articles/321030.php, (last visited May 29, 2019).
[46] Ibid.

Some of the epidemics they caused persisted for years and continued to kill more than 30,000 people in 1947, long after the Japanese had surrendered'[47].

Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on their Destruction in short, The Biological Weapons Convention (BWC) was the first multilateral disarmament treaty banning the development, production and stockpiling of biological weaponry or capabilities in 1972.[48] India is a signatory to the convention and has ratified the same.[49] However, there is no clear cut programme or evidence to suggest India's plan of action to implement the BWC.

TECHNOLOGY AND EXPORT CONTROLS

'The number, complexity and lethality of armed conflicts have increased, and there has been prolonged and shocking violence in large parts of the Middle East, Africa and South Asia.'[50] Geopolitical tensions and terrorist threats prompt governments to spend exorbitant amount of money on research and development of defence and global arms trade. Global arms trade facilitates non-concentration of advanced military technology with advanced nations and provides a fair ground for warfare. While defence technology transfer renders high sales values, the process is complicated especially considering obligations of contracting parties, intellectual property issues and political and geopolitical concerns. Sound transfer of technology policies and system is essential for efficient transfer and implementation of technology trade. Another important point to definitely ponder over is how and whether export policies shall be able to control technology transfer by non-licensed developers, often backed by terrorist intentions.

Global military spending is estimated to be $1822 billion in 2018, 76% higher than post-cold war era in 1998.[51] India is the fourth largest military spender, accounting for $66.5 billion and is the second largest arms importer.[52] According to Ministry of Defence (MoD)'s annual report, the

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[47] Friedrich Frischknecht, The history of biological warfare, National Center for Biotechnology Information, available at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1326439/, (last visited May 29, 2019).

[48] The Biological Weapons Convention, United Nations Office for Disarmament Affairs, available at https://www.un.org/disarmament/wmd/bio/, (last visited May 29, 2019).

[49] India: Signature of Biological Weapons Convention, United Nations Office for Disarmament Affairs, available at http://disarmament.un.org/treaties/a/bwc/india/sig/london, (last visited May 29, 2019).

[50] Stockholm Peace Research Institute, SIPRI YEARBOOK 2018 – Armaments, Disarmament and International Security, 1, (2018).

[51] Trends in World Military Expenditure, Stockholm Peace Research Institute, available at https://www.sipri.org/sites/default/files/2019-04/fs_1904_milex_2018.pdf, (last visited May 31, 2019).

[52] Trends in International Arms Transfers, Stockholm Peace Research Institute, available at https://www.sipri.org/sites/default/files/2019-03/fs_1903_at_2018.pdf, (last visited May 31, 2019).

export value in the year 2017-18 stood at ` Rs. 1937.75 crore from Rs. 1521.26 crore in financial year 2016-17.[53] India does not rank anywhere in the top 25 arms exporters as of 2018.[54]

History of India's Defence Industry with respect to Export & Import

The British colonial government set up the Board of Ordnance at Fort Wlliams, Calcutta in 1775. A gun powder factory was set up in 1787 which started operating from 1791. However, the first ordnance factory, Gun and Shell factory was set up in 1801 at Cossipore to manufacture guns and ammunition. 18 Ordnance Factories were set up by the time of independence. These ordnance factories only catered to repair and overhaul work of weapons and equipment procured in Britain, as the colonial government did not encourage development of industrialization in India and wanted the country to depend on Britain for its industrial needs. [55] . All the Ordnance Factories India obtained from the British Government formed the core of the state-led defence industry.

Post-independence the government emphasized on self-sufficiency in defence through its Industry Policy Resolution 1948 and The Industries (Development & Regulation) Act, 1951. The government reserved exclusive rights over the development of the defence industry. Defence Public Sector Undertakings (DSPUs) were set up to undertake defence production. The Defence Research & Development Organization (DRDO) was set up as an amalgamation of Technical Development Establishment (TDEs) of the Indian Army and the Directorate of Technical Development & Production (DTDP) with the Defence Science Organisation (DSO) in 1958. 'Defence allocation was low, and the R&D and industrial base at that time was poor. Between 1950-51 and 1960-61, the share of defence expenditure in the central government expenditure was reduced by more than half from 33 per cent to less than 16 per cent……..R&D was accorded low priority, with DRDO accounting for about one per cent of the defence budget in the 1960s. 18 This coupled with lack of a civil industrial base had a major impact on indigenous content and the production schedule.'[56]

India's war with China and Pakistan in 60s bought about a major change in India's defence policy and the share of defence expenditure in GDP has also increased.[57] Post 1962, India sought military assistance from foreign nations, including USA; but after USA had refused to supply military equipment to India during the India-Pakistan war of 1965, India began developing close defence relations with the Soviet Union.[58] India's war with China in 60s produced significant outcome in the defence industry - between 1962 and the mid-1980s, 11 ordnance factories were

[53] Ministry of Defence, Government of India, Annual Report 2017-18, (2018), available at https://mod.gov.in/sites/default/files/AR1718.pdf, (last visited June 11, 2018).

[55] Evolution of Defence Industry in India History Essay, UK Essays, (December 5, 2016), available at https://www.ukessays.com/essays/history/evolution-of-defence-industry-in-india-history-essay.php#ftn1, (last visited June 3, 2019).

[56] Laxman Kumar Behera, Indian Defence Industry, 6, (1st edition, Pentagon Press, New Delhi, 2016)

[57] Ibid, 7.

[58] Ibid.

established and DRDO laboratories were expanded to undertake research in aeronautics, electronics, naval technology, materials, life sciences and engineering equipment.[59] This phase witnessed focus on licensed production more than indigenous production. Although Soviet arms transfer and transfer of technologies increased India's military capacity, it did not increase the country's industrial and technological base.[60]

In the mid 1980s, the government empowered DRDO to take up high profile projects to encourage indigenous production; however, these incentives did not meet the growing demands of the armed forces.[61] Unlike complete licensed production, India shifted its focus to co-production/co-development. In 1998, India and Russia signed Inter Governmental Agreement for the development of supersonic cruise missile system – BrahMos.[62] Since, India has signed agreements with other countries for the development of defence and defence technologies.[63]

Despite private establishments, the country has been unable to look beyond DRDO for its defence technology requirements. 'The dependence on DRDO for technology has however not yielded the desired results. The DRDO despite its vast potential has been beset with many a problem leading to failures and cost and time overruns in the projects undertaken. This combined with the lack of R&D in industry and academia has compelled the country to source technology from outside, leading to a vicious cycle where initial import leads to another in successive fashion'[64] The country's heavy dependence on imports implies weak indigenous defence industry to meet domestic needs and questionably weak defence export value.

Privatisation

Private participation in the defence sector will enhance competition, increase efficiencies, facilitate faster and more significant absorption of technology – this will reduce the country's dependence on imports and shall gradually ensure greater self-reliance and dependability to meet national security needs in addition to contributing to exports for greater economic growth. The government reserved the exclusive right to produce and develop defence equipment and technology, until 2001, when the government privatized the defence sector – allowing 100% private participation subject to licensing, with the further provision of foreign direct investment

[59] Ibid.
[60] Ibid, 8.
[61] Ibid.
[62] History of BrahMos, BrahMos, available at http://www.brahmos.com/content.php?id=1&sid=2, (last visited June 2, 2019).
[63] Military Ties With Foreign Countries, Press Information Bureau, Government of India, (August 8, 2017) available at http://pib.nic.in/newsite/PrintRelease.aspx?relid=169712, (last visited June 3, 2019).
[64] Dr Laxman K Beherea, Make in India for Indian Defence, Indian Army, (March 2015), available at https://indianarmy.nic.in/writereaddata/documents/DSA300615.pdf (last visited June 17, 2019).

(FDI) of up to 26 per cent. Manufacturing in defence sector is governed through industrial licensing under

- the Industries (Development and Regulation) Act, 1951 – with no specific provisions relating to export of defence technology
- Arms Act 1959 – S.10 and S.11 deal exclusively with export of arms and ammunition, but has no provisions specific to defence technology exports
- Arm Rules 2016 – Similarly, S.43, S.45, S.72, S.87, S.90, S.91, and S.110 deal with export of arms and ammunition, but has no provisions specific to defence technology exports.

The private sector did not have easy access to contracts because of Ministry of Defence's (MOD) Defence Procurement Procedure (DPP) – which provides the guidelines and sources for capital procurement – did not have sufficient provisions to facilitate private participation; subsequent DPPs have included a host of provisions to enable easier private participation.

'Till 2001 the role of private companies in defence production was mainly restricted to supplying raw materials, semi-finished products, parts and components to the public sector units. After 2001, there has been a huge change in the private sector's involvement. This is clearly visible in the number of industrial licences (ILs) bagged by the private sector companies and their early success in winning contracts in direct competition not only with the established government-owned companies but also the foreign majors.' As of October 2017, Department of Industrial Policy and Promotion has issued 342 industrial licenses to 205 Indian companies in defence sector.[65]

However, the private industry has not yet made any significant contribution to India's defence industry and is continued to be dominated by the public sector units. The major reasons for this being firstly, MoD's failure to execute even a single major contract and secondly, 'the private continued to face difficulties in its foray into defence business. The difficulties arise because of the host of unresolved issues pertaining to industrial license, financial terms of engagement and level playing field vis-à-vis government owned entities.' In addition, the private sector's growth is also hindered by India's bureaucratic system. All the above factors disturb private sector's contribution to defence and technology, thereby also curbing defence technology exports due to lack of free growth environment.

[65] Frequently Asked Questions (FAQs), Department of Defence Production, available at http://makeinindiadefence.gov.in/faqs/index/2, (last visited June 3, 2019).

Defence Production Policy

The government's outspoken advocacy on self reliance since independence has built up capabilities in DRDO, DPSUs and Ordnance Factories to meet the requirements of the armed forces. To further the goal of indigenisation, the Government have set up the Defence Production Policy in 2011 to increase substantive self reliance in the design, development and production of defence equipment and technologies and to encourage private and SMEs (small and medium enterprises) to broaden the defence industry.

The policy stipulates that preference will be given to Indian manufacturers to meet defence needs wherever indigenous dependence was possible. Whenever the Indian industry is not in a position to meet defence needs, the equipment and technology shall be sourced from foreign nations in accordance with DPP. Prior to foreign procurement, the time, resources and urgency of defence needs required for indigenous production would be thoroughly examined. The policy also encourages private participation, joint ventures and partnerships to build a robust defence industry by special policy formulation as well as allocation of funds for research and development of the same. It simplifies the procedures stipulated in DPP with a view to enable easier indigenous design and development by both public and private industry in a faster time frame.

A major shortcoming of this policy was lack of concrete R&D or manufacturing plan, which is the minimum necessary condition to enable the industry to commit any investment. In the absence of a concrete plan, DRDO on its own has 'prepared a Long Term Technology Perspective Plan (LTTPP) based on its own study and understanding of system requirements as laid down in the armed forces' 15-year Long Term Integrated Perspective Plan (LTIPP). The aim of DRDO's LTTPP is to 'align [its] technology development plan with systems acquisition plan given in LTIPP.'[66] Unlike LTIPP, LTTPP does not have government sanction, paving way for non-cooperation by other stakeholders, particularly the armed forces, who may feel that DRDO's efforts do not meet their requirements.[67] In addition, there is no accountability with respect to key deliveries in a stipulated time-frame.[68]

The government has drafted another 'Draft Defence Production Policy' (Draft Policy) in 2018 considering India's continued dependence on imports, despite significant progress. Unlike the previous policy, the Draft Policy stipulates clear cut, focused and strategic guidelines to achieve cost effective strategic independence. The Draft Policy aims to achieve the following goals by 2025: self reliance in the development of 13 specific weapon systems/platforms, a turnover of Rs 1,70,000 Crores (USD 26 Bn approx) in aerospace and defence goods and services involving additional investment of nearly Rs 70,000 Crores (USD 10 Bn approx), to achieve export of Rs 35,000 Crores, to make India as a global leader in Cyberspace and AI technologies, inculcation

[66] Ibid.
[67] Ibid.
[68] Ibid.

of zero defect zero effect culture amongst MSMEs (micro, small and medium enterprises) and to create an environment that encourages R&D, rewards innovation, creates Indian IP ownership and robust and self-reliance defence industry.

However, there are doubts whether the goals stipulated in the Draft Policy are realistic considering India's current technology capabilities. Although it is one of the largest military spenders, the country is heavily dependent on imports for defence needs. 'To put the country among the top-five aerospace and defence manufacturing countries, as the draft policy's vision states, would mean India joining the ranks of such countries as US, Russia, France, UK and China, which are presently the global leaders in arms production. To join such a coveted club would also mean some of the established Indian defence manufactures breaking into the club of top global arms producers.'[69]

India does not rank anywhere in the top 25 arms exporters as of 2018.[70] It's export value in the year 2017-18 stood at Rs. 1937.75 crore.[71] According to a report of top 100 defence companies, Hindustan Aeronautics, stands at rank 38 and Bharat Electronics at rank 59.[72]

There is no doubt that India's defence technology capability has substantially increased over the past few decades, but it is still backward due to lack of sound indigenous defence industrialization. Considering the above figures and the country's general technology backwardness, it is doubtful whether the goals stipulated in the Draft Policy are realistic; especially since the country's continued heavy reliance on imports and modest exports base even in 2018. To attain the status of 'global leader', India must surpass technology capabilities of several nations ahead of it, let alone developed nations like USA and Russia. It is questionable whether such a status can be achieved by 2025 bearing in mind fast-paced global technological advancements and India's global indigenous technology incapability, when there are accounts of armed forces rejecting Made in India rifles.[73]

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[69] Laxman K Behera, Draft Defence Production Policy 2018: Challenges Galore, Institute for Defence Studies and Analyses, (April 4, 3018), available at https://idsa.in/idsacomments/draft-defence-production-policy-2018%3A-challenges-galore-lkbehera-040418 , (last visited June 10, 2019).

[70] *Supra note 5.*

[71] *Supra note 4.*

[72] Jill Aitoro, The list is here: The largest defense companies on the globe, revealed, Defense News, (August 13, 2018), available at https://www.defensenews.com/top-100/2018/08/09/the-list-is-here-the-largest-defense-companies-on-the-globe-revealed/, (last visited June 11, 2019).

[73] PTI, Indian Army rejects Made in India rifles for 2nd year in a row after they failed miserably during trials, The Economic Times, (July 14, 2018), available at https://economictimes.indiatimes.com/news/defence/indian-army-rejects-made-in-india-rifles-for-2nd-year-in-a-row-after-they-failed-miserably-during-trials/articleshow/59257363.cms?from=mdr, (last visited June 11, 2019).

Imports

Apart from indigenous development, the other route to acquire defence technology is through import. 'Transfer of Technology' (ToT) refers to arrangements wherein foreign supplier provides the domestic buyer 'technology' to manufacture defence equipments. 'Since indigenous capability was limited, India has been using ToT to shore up its defence production capabilities from as far back as the 1960s and 1970s'.[74]

'Relying on imports from first tier arms producing countries has positives and negatives. On one hand, it has ensured and enhanced India's defence capability, but on the other it has constrained indigenous research as technology has been imported rather than developed. Though these arms purchases are done with technology transfer and offset arrangements, India still lags behind the developed countries defence industry standards.'[75]

India's failure to develop a sound defence industry has forced the government to spend copious amount of money on imports; to an extent that even in cases of transfer of technology, India did not particularly succeed in localizing transferred technologies due to 'difficulties in local industrial production, lack of skilled labour and low adherence to technological requirements.'[76]

Export and Policy

Strategy for Defence Exports

The government has always felt the need for self reliance and indigenisation in defence for both strategic and economic reasons for which effective R&D is essential. The government felt that the domestic defence industry would have limited scope for investment in R&D and production if it relies only on the domestic demand. It felt the need to supplement the defence industrial policy by the 'strategy for defence exports' (Hereinafter, strategy) which is essential to sustain the present economic competitive environment. The strategy aims to assure the defence industry access to export markets along with domestic markets. The Ministry of Commerce & Industry already has an export policy in the name of Foreign Trade Policy (FTP) but the government felt the need to prepare a specific strategy to encourage defence exports.

But the strategy is too generic in nature and does not provide any concrete policy or base to regulate defence technology exports. The DPP also has similar drawbacks. Despite extensive

[74] Kevin A. Desouza, Transfer of Defence Technology: A Crtical Analysis, Institute for Defence Studies and Analyses, (April 12, 2016), available at https://idsa.in/idsacomments/transfer-of-defence-technology_ka-desouza_120416, (last visited June 11, 2019).

[75] Why is India still the world's largest arms importer?, The Conversation, (April 15, 2014), available at https://theconversation.com/why-is-india-still-the-worlds-largest-arms-importer-25462, (last visited June 10, 2019).

[76] Ksenia Zubacheva, Why India fails to fully localise Russian defence technology, Russian Beyond, (March 15, 2017), available at https://www.rbth.com/defence/2017/03/15/minor-obstacles-hamper-transfer-of-military-technology-from-russia-to-india_720123, (last visited June 11, 2019).

research conducted, no evidence or clear cut policy was found to understand the regulation of defence technology exports. While there are laws to regulate exports, they're not technology specific. This suggests either of the situations

- The country does not export defence technology to foreign nations
- The country's contribution of defence technology is insignificant

Defence equipment and functioning in the 21st century is incomplete without technology; and for this very reason, it is essential that the country formulates specific laws, policies, structures and mechanisms to identify, research and develop technologies. Despite DRDO's active presence ever since its inception, in addition to private players since the 2000s, the mere fact that India imports majority of its equipment and technology suggests that India has a weak indigenous defence industry with several lacunae including that of policy, corruption and bureaucracy.

It is often heard of that with the proliferation of technologies like cyber war and artificial intelligence, we must prepare for non contact warfare that have just as capacity to cause severe damage like that of conventional war. India must be prepared for such a situation, but the current scenario of the defence industry, its bureaucracy and numerous policy gaps make the country extremely vulnerable to threats from state and non-state actors. It must be acknowledged that with such a situation prevailing in the country, it shall pave the way for non-state actors to carry out malicious activities.

To attain such preparedness, India must also have sound economy, which is highly dependent on indigenous defence technology production and their exports.

NEW TECHNOLOGIES AND LEGAL POLICIES: THE LEGAL GAP

Defence technology forges the way security threats are understood, prevented or fought. Advanced technologies in defence enable a nation to have not only indigenous and economic advantages, but it also provides an edge in international relations and war supremacy. States spend copious amounts on the research and development of advanced defence technologies for this very reason. 'Defense R&D has been widely criticized since the 1970s in the economic literature because of its opportunity cost and its relative ineffectiveness compared to civilian R&D'.[77] Technology, ever since its inception, is characterized by fast-paced developments, often too fast for the society to even understand, let alone catch up. While advancements in defence

[77] Renaud Bellais, Technology and the defense industry: real threats, bad habits, or new (market) opportunities?, Journal of Innovation and Economics Management, CairnInfo, available at https://www.cairn.info/revue-journal-of-innovation-economics-2013-2-page-59.htm#, (last visited June 12, 2019).

technology are of great value, policymakers must ensure they are in tune with existing laws. However, each technology has its own identity and often may require separate attention for its accommodation into defence; and policy makers often lag behind and find it difficult to cope up with fast paced technological advancements. Understanding the scope of technology is at times difficult; some of its biggest bugs or problems only come to knowledge as and when they arise.

The disarmament of all weapons of mass destruction only happened after those weapons had caused their intended destruction; The Chemical Weapons Convention (CWC) had come into force in 1992 after considering the deaths of French and Algerian forces in Ypres in World War I, Treaty on the Non-Proliferation of Nuclear Weapons (NPT) in 1968 after the mass destruction in Hiroshima & Nagasaki during World War II and The Biological Weapons Convention (BWC) in 1972 after the Chinese poisonous massacre during the Second World War. All these weapons were technologically advanced during their time and their possession enabled the capable country to attain supremacy in war. The international disarmament measures had prevented States from the usage of such weapons. These disarmament measures had helped in the advocacy of non-proliferation of such weapons in non-participating countries as well; for instance, despite not signing the Treaty on Non-proliferation of Nuclear Weapons, India is well aware of nitty-gritty's of nuclear weapons, has a No-First Use doctrine[78] and also seeks to be a member of Nuclear Suppliers Group. The United Nations Office for Disarmament Affairs, established in 1998, 'fosters disarmament measures through dialogue, transparency and confidence-building on military matters, and encourages regional disarmament efforts….'[79]

However it cannot be forgotten that the disarmament of such advanced technologies emerged at the cost of massacre and suffering. Thanks to international organizations and dialogue, advanced technology affairs are predictable, announced and/or transferred, however, the extent to which that shall happen, especially considering international tensions and whether emerging technologies will cause similar effects are questions one can definitely ponder over. The accommodation of advanced defence technologies and their legal regulation may start with acknowledging its unpredictable nature, so as to inculcate them as and when they develop.

Below are some of the latest technologies.

Artificial Intelligence (AI)

It is the development of computer softwares and systems able to perform tasks that normally require human intelligence. The ideal characteristic of artificial intelligence is its ability to rationalize and take actions that have the best chance of achieving a specific goal. (AI) is

[78] This doctrine dictates that nuclear weapons will only be used in retaliation against a nuclear attack on Indian Territory or on Indian forces anywhere.
[79] About Us, United Nations Office for Disarmament Affairs, available at https://www.un.org/disarmament/about/, (last visited June 13, 2019).

becoming a critical part of modern warfare. Compared with conventional systems, military systems equipped with AI are capable of handling larger volumes of data more efficiently. Additionally, AI improves self-control, self-regulation, and self-actuation of combat systems due to its inherent computing and decision-making capabilities. For instance, Military systems are often vulnerable to cyber attacks, which can lead to loss of classified military information and damage to military systems; however, systems equipped with AI can autonomously protect networks, computers, programs, and data from any kind of unauthorized access. In addition, AI-enabled web security systems can record the pattern of cyber attacks and develop counter-attack tools to tackle them.

Such technological capabilities have the ability to disrupt international balance of powers. China is spending copious amounts on artificial intelligence in defence and India cannot be left behind.[80] An Army Chief notes that it will be too late if India doesn't incorporate AI soon enough into its armed forces.[81] India needs to address how to incorporate AI into its system and not just adding it to the military glossary.[82]

However, Centre for Artificial Intelligence and Robotics (CAIR), established in 1986, a premier laboratory of DRDO, has been working towards developing AI systems for defence. 'As per reports, DPSU has been directed to build AI-enabled products and AI-based tools for sensor data analysis, predictive maintenance and situational awareness. A INR 73.9 crore project has been sanctioned under CAIR to build AI-based solutions to improve intelligence collation and analysis capabilities of Indian defence. In a similar vein, another project called Energy Harvesting Based Infrared Sensor Network for Automated Human Intrusion Detection was sanctioned for about INR 1.8 crore.'[83] Indian institutions like IIT Hyderabad are offering courses are offering courses in AI. 'NITI Aayog, Intel, and Tata Institute of Fundamental Research (TIFR) joined hands together to set up a Model International Center for Transformative Artificial Intelligence (ICTAI) towards developing and deploying AI-led application-based research projects. This initiative is part of NITI Aayog's 'National Strategy for Artificial Intelligence'[84]

[80] PTI, Army Chief for tapping AI, Big Data for defence forces, The Economic Times, (Jan 11, 2019), available at https://economictimes.indiatimes.com/news/defence/army-chief-for-tapping-ai-big-data-for-defence-forces/articleshow/67620009.cms?from=mdr, (last visited June 17, 2019).

[81] PTI, Will be too late if work doesn't begin on incorporating AI into armed forces' system: General Rawat, The Economic Times, (January 11, 2019), available at https://economictimes.indiatimes.com/news/defence/will-be-too-late-if-work-doesnt-begin-on-incorporating-ai-into-armed-forces-system-general-rawat/articleshow/67488784.cms?from=mdr, (last visited June 17, 2019).

[82] Ibid.

[83] Richa Bhatia, India Doubles Down on Use of AI in Defence With AI-Enabled Night Vision device, Analytics India Magazine, (January 3, 2019), available at https://www.analyticsindiamag.com/india-doubles-down-on-use-of-ai-in-defence-with-ai-enabled-night-vision-device/, (last visited June 17, 2019).

[84] Ram Sagar, How Does India's AI Strategy fare visa-avis its US Counterpart?, Analytics India Magazine, (February 25, 2019) available at https://www.analyticsindiamag.com/how-does-indias-ai-strategy-fare-vis-a-vis-its-us-counterpart/, (last visited June 17, 2019).

However, despite these developments, there has not been significant AI incorporation and lack of clear policies has hindered its development. India has to overcome the below challenges to incorporate AI into armed forces[85]:

- Lack of enabling data ecosystems:
- Low intensity of AI research
- Core research in fundamental technologies
- Transforming core research into market applications
- Inadequate availability of AI expertise, manpower and skilling opportunities
- High resource cost and low awareness for adopting AI in business processes
- Unclear privacy, security and ethical regulations
- Unattractive Intellectual Property regime to incentivise research and adoption of AI.

The face of India's economic, geopolitical and military capabilities shall revolutionize if India is capable of incorporating AI; but this entails for stringent policies for adoption and innovation of AI.

Big Data Analytics

Technology generates data whenever any activity over the internet is conducted, from browsing to social media usage; the data so produced leaves a digital trail of information. This data is very complex, has multiple sources and is spontaneous (real-time).[86] This is Big Data. Businesses spend copious resources to collect and analyse big data to create customized and improvised product/service experience for their customers. Big data is an evolving term that describes a large volume of structured, semi-structured and unstructured data that has the potential to be mined for information and used in machine learning projects and other advanced analytics applications.[87] Big Data doesn't necessarily equate to any specific volume of data, the term is often used to describe terabytes, petabytes and even exabytes of data captured over time.

It is often said future wars will be determined by smart machines. 'Intelligence is at the heart of all defence planning and implementation. With data now becoming available from every angle

[85] Ibid.
[86] Ronald van Loon, What is Big Data and How does it Work?, Data Science Central, (December 12, 2017), available at https://www.datasciencecentral.com/profiles/blogs/what-is-big-data-and-how-does-it-work, (last visited June 24, 2019).
[87] Margaret Rouse, Big Data, TechTarget Search Data Management, (November 2018), available at https://searchdatamanagement.techtarget.com/definition/big-data, (last visited June 24, 2019).

possible, a change in approach is paramount so that all of this information can be put to the best use.'[88] National security and defence related data being generated from multiple sources will have to be carefully analysed for national decision-making, military operations and better situational awareness in the future. 'Today, machine data is generated by the movement of ships, aircraft and vehicles, satellites in space, drones, Unmanned Aerial Vehicles (UAVs), reconnaissance aircraft, sensors and Battle Field Surveillance Radars (BFSR). Human generated data include data from social media sites like YouTube, Facebook, Twitter, etc. Business data is generated from all e-commerce transactions. All these data have intelligence which we cannot afford to miss in the future. Big data analytics will be utilised for intelligence gathering in the near future since inputs for national and military intelligence are obtained continuously during peace and war, the quantum increasing exponentially during crises and war. Human analysis of this information and intelligence data is well beyond physical capability; therefore, big data analytics-based intelligence will provide the requisite output for decision-making and conduct of operations. Big data analytics can give a big boost to intelligence gathering…….'[89]

The UK Defence Secretary announced a £800-million fund that supports projects that include Big Data and predictive analysis.[90] 'The US Argus ground surveillance system collects more that 40GB of information per second. It is an autonomous Real Time Ground Ubiquitous Surveillance Imaging System and has a 1.8 gig pixel video camera with 12 frames per second (fps) and 368 sensors. It collects 6,000 terabytes of data/imagery per day and feeds it to Home Land Security. Post 9/11, this has served as a big deterrent.'[91]

As far as India is concerned, a 2018 article reports that experts had stated that a road map has already been implemented, focussing on the application of Big Data analytics in the armed forces. However, in an event in 2019, Army Chief Bipin Rawat had stated that it is high time India focused on Big Data analytics rather than "confining it to mere definitions",[92]

This implies that the country has not yet incorporated Big Data into its defence systems. 'Lt. General Anil Kapoor, Director General, Information System, brought out the fact that data was being treated as the next oil and mentioned that Indian Army was in the process of redefining

[88] Nikunj Thakkar, Future of Defence: Big Data and Military Intelligence, Medium, (August 14, 2018), available at https://blog.dataone.io/future-of-defence-big-data-and-military-intelligence-9be941f1a494, (last visited June 25, 2019).
[89] Haridas M, Redefining Military Intelligence in Big Data Analytics, Centre for Land Warfare Studies, (2015), available at https://www.claws.in/images/journals_doc/1511401708_RedefiningMilitaryIntelligenceUsingBigDataAnalytics.pdf, (last visited June 25, 2019).
[90] Amrita Nair Ghaswalla, Big Data Analytics to steer military intelligence, The Hindu Business Line, (Janruary 10, 2018), available at https://www.thehindubusinessline.com/news/big-data-analytics-to-steer-military-intelligence/article9864088.ece, (last visited June 25, 2019).
[91] Ibid.
[92] Harshajit Sarmah, Army Chief Bipin Rawat Says India Should Focus On AI And Big Data Computing, Analytics India Magazine, (January 21, 2019), https://www.analyticsindiamag.com/army-chief-bipin-rawat-india-focus-ai-big-data-computing/, (last visited June 25, 2019).

and refining legacy applications into state-of-the-art software by using contemporary technologies.'[93] But this can't happen effectively and efficiently until and unless there's a governing mechanism established to understand the relevance and incorporation Big Data into defence. Apart from the above statements, there is no evidence to suggest whether Big Data incorporation in defence. Absence of a policy or a system through which new technologies are understood, introduced and further developed hinders the growth of technologies like Big Data in defence, further bridging the technological gap between countries like China, USA and India.

Cyber-warfare

Cyber warfare is any virtual conflict initiated as a politically motivated attack on an enemy's computer and information systems. Waged via the Internet, these attacks disable financial and organizational systems by stealing or altering classified data to undermine networks, websites and services. Cyber war can happen in two ways:

1) 'Espionage – learning of information not meant to be learnt, that is both strategic and tactical: information about troop movements, the strengths and weaknesses of weapon systems, the dispositions of various and anything else about sensitive resources that might be important to know.

2) Sabotage – also called 'direct action', in cyber warfare, sabotage can be something as benign as dropping a government's website to causing a nuclear meltdown at a nuclear plant.'[94]

India is among the top five nations affected by the complex cyber attacks and such attacks would multiply with the technological advancement.[95] Lt. General (retd) D.S. Hooda recently told IANS that "with critical infrastructure and military installations getting connected through the internet, the threat of cyber attacks was becoming increasingly lethal and that an emerging India was particularly at risk of such attacks."[96] Former National Security Adviser M.K. Narayanan had stated that India needed to upgrade its old crypto protocols to prevent major security breach

[93] PTI, Armed forces repository of big data, need to carry out analytics using AI: Army Chief , The Economic Times, (June 5, 2018), available at https://economictimes.indiatimes.com/news/defence/armed-forces-repository-of-big-data-need-to-carry-out-analytics-using-ai-army-chief/articleshow/64468837.cms?from=mdr , (last visited June 25, 2019).

[94] How does cyber warfare work?, Forbes, (July 18, 2013), available at https://www.forbes.com/sites/quora/2013/07/18/how-does-cyber-warfare-work/#6376dc8b44ce, (last visited June 17, 2019).

[95] IANS, India should strengthen cyber warfare capabilities: Narayan, The Economic Times, (January 16, 2019), available at https://economictimes.indiatimes.com/news/defence/india-should-strengthen-cyber-warfare-capabilities-narayanan/articleshow/67555647.cms?from=mdr, (last visited June 17, 2019).

[96] Is India ready for a cyber attack?, The Quint, (February 26, 2017), available https://www.thequint.com/tech-and-auto/tech-news/indian-airstrikes-cyber-warfare-preparedness-where-it-stands, (last visited June 17, 2019).

that has the capability to adversely affect the country.[97] India currently ranks third if terms of cyber warfare threats, but unfortunately ranks 23rd when it comes to having the capacity to deal with them.[98] Such statistics call for an urgent up gradation of rules, systems and policies to efficiently combat cyber threats.

Since 2018, efforts have been made to recruit individuals from the armed forces for The Defence Cyber Agency, coordinating with National Cyber Security Advisor, which shall have both defensive and offensive capacity.[99] Considering the vulnerability and nature of cyber war, specialised legislations and policies are essential to develop cyber war preparedness.

Bioterrorism and biological weapons

High rate of population, sanitation and poor hygienic facilities, and congenial climatic environment make India especially vulnerable to diseases caused by biological agents. Absence of adequate medical facilities[100] and hostile relations with neighbouring countries further leave India vulnerable. It's also very difficult and time consuming for research authorities to differentiate between the nature and type of biological agents i.e., whether they're natural or man-made and how to deal with them.

Ever since The Biological Weapons Convention (BWC), rapid developments in the field of biology have led to the proliferation of knowledge and equipment across the globe. 'With growing interest in using biotechnology for other industrial uses such as bio-fabrication, bio-electronics, bio-sensors and even digital organisms and environmental remediation, the biotechnology industry undoubtedly continues to grow.'[101] This proliferation implies the capacity of dual-use biotechnology of several nations and individuals with several social, economic, industrial and/or malicious purposes. 'The deskilling of technologies will translate to increasingly more sophisticated biotech in the hands of a greater number of people, less education and skill required to use increasing this equipment and tools, and at lower costs for using these capabilities. In short, the thresholds for use of the technology will be dramatically lowered'.[102]

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[97] Ibid.
[98] Ibid.
[99] ET Online, India is quietly preparing a cyber warfare unit to fight a new kind of enemy, The Economic Times, (July 14, 2018), available at https://economictimes.indiatimes.com/news/defence/india-is-quietly-preparing-a-cyber-warfare-unit-to-fight-a-new-kind-of-enemy/articleshow/61141277.cms?from=mdr, (last visited June 17, 2019).
[100] PTI, India 145th among 195 countries in healthcare acess, quality: Lancet, The Times of India, (May 23, 2018), available at https://timesofindia.indiatimes.com/india/india-145th-among-195-countries-in-healthcare-access-quality-lancet/articleshow/64283179.cms, (last visited June 20, 2019) .
[101] Daniel M Gerstein, Time to Bolster Global Biological and Chemical Defence Capabilities, Institute of Defence Studies and Analyses, (June 2019), available at https://idsa.in/cbwmagazine/global-biological-and-chemical-defense-capabilities, (last visited June 20, 2019).
[102] Ibid.

Although there have been no reports of their military usage/weapon of mass destruction, there have been reports of their individual development despite BWC. In 2018, a man in Germany suspected to have contact with terrorist organizations, was arrested for production of ricin (dangerous toxin) for the development of a biological weapon.[103] In 2015, a man from Liverpool was jailed for 8 years for attempting to purchase ricin on the internet and had in fact been in contact with an undercover FBI agent.[104] In 2003, seven men were arrested on suspicion of planning an attack on the London Underground using ricin and only one of them was convicted.[105] In 2001, US Senate offices and media outlets received Anthrax contaminated letters.[106]

US officials warned India in 2010 that terrorists could easily find the material they need for bioterrorism in India and use the country as a base for launching an international campaign involving the spread of fatal diseases.[107]

Defence Research and Development Organization (DRDO)'s primary lab of biotechnology, the Defense Research and Development Establishment (DRDE), is located in Gwalior, Madhya Pradesh. The DRDE is the primary establishment for studies in toxicology, biochemical pharmacology, and the development of antibodies against several bacterial and viral agents. Work here centres on countering disease threats such as anthrax, brucellosis, cholera, plague, smallpox, viral haemorrhage fever, and botulism. India indigenously developed its own NBC (nuclear, biological, chemical) recce (reconnaissance) vehicle which monitors radiologically and chemically contaminated areas.[108]

A bioterrorist attack maybe an unlikely or a rare event, but it shall have extreme consequences. The BWC has been criticized for its ambiguous language and for a lack of a verification mechanism to check whether the signatory is abiding the norms of the convention. While the convention prevents the creation, use, stockpiling or exchange of any bioweapon, the definition of 'bioweapon' is ambiguous; the convention allows the stocking of pathogenic agents in small quantities for peaceful purposes, however unlike chemical or nuclear weapons, small quantities

[103] Justin Huggler, Islamist extremist ricin plot foiled by German police, Telegraph, (June 14, 2018), available at https://www.telegraph.co.uk/global-health/terror-and-security/islamist-extremist-ricin-plot-foiled-german-police/, (last visited June 20, 2019).
[104] Ibid.
[105] Ibid.
[106] Prashant K Singh, Bio-terrorism — an invisible, asymmetric threat to India, DNA India, (May 30, 2019), available at https://www.dnaindia.com/analysis/column-bio-terrorism-an-invisible-asymmetric-threat-to-india-2755007, (last visited June 20, 2019).

[107] Jason Burke, WikiLeaks cables: US officials voiced fears India could be target of biological terrorism, Telegraph, (December 16, 2010), available at https://www.theguardian.com/world/2010/dec/16/wikileaks-india-biological-terrorism-fears, (last visited June 20, 2019).

[108] Rahul Chandawarkar, India's first NBC recce vehicle launched in Pune, DNA India, (December 22, 2010), https://www.dnaindia.com/mumbai/report-india-s-first-nbc-recce-vehicle-launched-in-pune-1484520, (last visited June 22, 2019).

of biological agents can be easily used for malicious purposes, defeating the very purpose of BWC.[109] What's even more worrisome is the lack of data available as to how India will take care of such a situation, especially in the absence of any evidence or clear-cut policy to implement the BWC. India needs to implement the following policy recommendations to combat bio-threats:

- 'Surveillance mechanisms at grass root levels
- To increase the standards of bio safety and health care
- Leadership at the BWC
- Public engagement'.[110]

Conclusion

It's not clear whether India acknowledges the many new developing technologies and/or whether the laws and policies are accommodating. The country is in dire need of a structure to identify, research and incorporate technologies into defence.

The Long Term Integrated Perspective Plan (LTIPP), a document that lays down the needs of armed forces for a 15year period, through another document known as the Technology Perspective and Capability Roadmap is born that lists out technologies and plans, should ideally guide the defence industry in product and technology innovation and development. But the document is too generic in nature and does not provide any concrete base or policy for the defence industry to plan.[111] "…there is no system whereby the armed forces can provide advance information to the industry so as to enable the latter to come up with detailed financial, technological and industrial plans to meet the requirements in a time frame that is acceptable to the armed forces."[112] In the absence of any concrete system or policy to govern and accommodate latest defence technologies, let alone innovation and development, the country's defence budget shall continue rocketing without any increment in the it's technological and industrial capabilities.

In addition to this, DRDO is the biggest establishment responsible for technology development, innovation and production of defence equipment and technology, which does not have a clear cut

[109] Shambhavi Naik, Biological Weapons: The Impact of New Technologies, Institute of Defence Studies and Analyses, (June 2019), available at https://idsa.in/cbwmagazine/Biological-weapons-snaik, (last visited June 23, 2019).

[110] Ibid.

[111] Arvind Gupta, A former national security advisor explains how India can modernise its military tech, Quartz India, (August 16, 2018), available at https://qz.com/india/1360460/india-must-look-beyond-drdo-for-defence-modernisation/, (last visited June 17, 2019)

[112] Dr Laxman K Beherea, Make in India for Indian Defence, Indian Army, (March 2015), available at https://indianarmy.nic.in/writereaddata/documents/DSA300615.pdf (last visited June 17, 2019)

policy or evidence to suggest how it identifies and incorporates latest technologies. The organization runs in an ambiguous nature, further adding on the lacunae between technology and policy. The defence industry is often criticized for the delays in product and technology innovation and development, but this entirely cannot be blamed on the industry. 'It is a part of the innovation ecosystem that is not geared to deliver products on time. The armed forces are its only customers. They project their plans of acquisitions and technology through the LTIPP, which as stated above is generic and does not provide a concrete base for planning and implementation of armed forces needs. 'For instance, the document says that the armed forces will require space-based sensors but does not provide either the numbers that would be needed or their parameters. In the absence of such details the DRDO is unable to start its work…..The actual details are usually made available only when the armed forces begin to acquire a product. By that time it is too late to design it indigenously.'

The country must also look beyond DRDO for its defence technology needs. DRDO acts like a monopoly in the defence industry despite private players. 'The dependence on DRDO for technology has however not yielded the desired results. The DRDO despite its vast potential has been beset with many a problem leading to failures and cost and time overruns in the projects undertaken. This combined with the lack of R&D in industry and academia has compelled the country to source technology from outside, leading to a vicious cycle where initial import leads to another in successive fashion'. This again can be attributed to lack of a structure or policy on how the organization functions.

Despite technological advancements in the civil arena, their defence assimilation is severely hindered. The private defence industry has not yet made any noteworthy significant contribution to the industry. The major reasons for this being firstly, MoD's failure to execute even a single major contract and secondly, 'the private continued to face difficulties in its foray into defence business. The difficulties arise because of the host of unresolved issues pertaining to industrial license, financial terms of engagement and level playing field vis-à-vis government owned entities.'[113]

[113] Laxman Kumar Behera, Indian Defence Industry, 13, (1st edition, Pentagon Press, New Delhi, 2016)

MODULE-III

Defence Industry and Transfer of Technology Agreements

India's journey towards the acquisition of competitive defence technology so as to gain assured capability against the military threats it confronts, has essentially two routes. The first route is indigenous development and the second, import of technology. Despite considerable thrust on the first, albeit with an understandably limited budget, the progress towards self-reliance in defence technology has not reached the milestones that were set. There is no doubt that overall indigenous development and production has significantly increased in technology levels and volumes over the decades. However, this has been offset by an even faster evolution of defence technology in the world. The Indian defence forces thus continue, as in the past, to depend on imported competitive defence technology systems.

Can this technology gap be reduced? There is no doubt that a deep commitment and investment in indigenisation can achieve this reduction, as has been demonstrated in the Indian space and, to some extent, nuclear technology domains. However, financial constraints in India's developing economy has precluded such an investment. Consequently, Indian defence technology still lags behind in most fields and many frustrating attempts to push harder on the indigenous route do not seem to help. It is in this discouraging environment that we find a few references which allude to the 'unnecessary need to re-invent the wheel' and the use of the second route, that is, import through transfer of technology (ToT), as a 'jumping board' or a means of 'leap-frogging over the technology lag'.

This module takes a close look at ToT, the second route, going through a brief historical perspective, an analysis of its alignment with national goals, defining it and understanding its nuances, its benefits and costs as well as trade practices which restrict its exploitation by the recipient country. Further nuances, such as the effect of export control regimes (Missile Technology Control Regime [MTCR], Wassenaar Arrangement et al.) and commercial modes such as foreign direct investment and joint ventures, are planned to be covered in a separate article subsequently. It is also planned to cover the current situation in the Indian defence industry subsequently since data is not yet available.

Historical Perspective

India's journey towards production of competitive defence technologies commenced with the Ordnance Factories (OFs), which were established with British technology in the 1800s and 1900s. These were utilised to some extent for meeting the domestic needs of the subcontinent and that of the two world wars. Since their capabilities were limited, the decade post-independence saw the direct acquisition of weapons systems from major military powers. Simultaneously, a start was made in the 1950s to establish a defence industrial base (DIB) by setting up of the Indian Defence Research and Development Organisation (DRDO), which was tasked to indigenously design and develop defence systems for the Indian military services. This was accompanied by the establishment of a few defence public sector undertakings (DPSUs),

which would take on the manufacturing of defence systems. The next few decades saw collaborative military production (a variant of today's ToT) programmes of foreign weapon systems such as the Alouette helicopters, 106 mm recoilless guns, Nissan jeeps, Shaktiman trucks and Gnat fighter aircraft from the French, the United States (US), Japan(Nissan), West Germany (MAN) and Britain (Folland Aircraft) respectively. Early in the 1960s, India approached the British to allow licenced manufacture (LM) (another variant of ToT) of the Lightning fighter aircraft. This was refused; hence, the Soviet Union was approached and in 1962 an agreement was struck to produce the MiG-21 fighter aircraft in India. This was the start of a long defence technology relationship with the Soviet Union. By the 1980s, nearly 70 per cent of Indian military hardware was of Soviet origin. India, however, also maintained an open stance for receiving LM offers from other major powers, such as Britain, France, Germany and other European countries.

The LM (or ToT) as the preferred means of acquiring high-population major defence systems was not entirely successful. In the MiG-21 programme with the Soviet Union, shortages of trained manpower and poor-quality facilities hampered production, which was limited to the assembly of subsystems and major parts. Complaints of poor quality of the produced aircraft also plagued Hindustan Aeronautics Limited (HAL), the DPSU which produced the aircraft. Delayed timelines due to various reasons forced the outright purchase of more aircraft, such as the 50 Hunters from the United Kingdom (UK) and 150 Su-70s from the Union of Soviet Socialist Republics (USSR).

In the 1980s and 1990s, the Indian DIB showed signs of being able to deliver some indigenous systems. Some of the well-known programmes are the main battle tank (MBT), the light combat aircraft (LCA) and a string of missiles systems under the Integrated Guided Missile Development Programme (IGMDP). Progress, however, was slow and many voids in other fields of military capability existed. Hence, LM (ToT) continued for the induction of large-population systems such as the T-90 tanks, armoured fighting vehicle BMP-II, Bofors FH 177B artillery guns, Flycatcher radars and Reporter radars.

In 2001, the Indian government decided to take a quantum step ahead in its economic liberalisation policy by opening the defence sector to private companies. In order to maintain a transparent and efficient process, the Ministry of Defence (MoD) drew up and promulgated the Defence Procurement Procedure (DPP) in 2003. This would guide all the connected agencies and enable faster processing of acquisitions in the desired competitive scenario. LM under the head 'ToT', was included in the DPP and its subsequent revisions.

In recent times, despite the introduction of a number of indigenous systems such as the MBT Arjun, advanced light helicopter (ALH) Dhruv and Akash air defence weapon systems, imports have continued unabated. In fact, India is one of the largest importers of military equipment in the world today. Among the systems being imported, many are being manufactured or are proposed to be manufactured under ToT. These include the Sukhoi Su-30 fighter aircraft, the

Scorpene submarine, the long range surface-to-air missile (LRSAM), the low-level transportable radar (LLTR) and many others.

In 2008, defence offsets were introduced in the DPP. These provisions were subsequently revised and a Defence Offset Guidelines issued in 2012. These guidelines listed six different avenues for their execution. Out of these, three pertain to some form of ToT, indicating the significance being accorded by the Indian government to the field. Whether offsets have been successful in enabling productive ToT, however, is not yet clear.

On 25 September 2014, the Indian government launched the 'Make in India' campaign, with the primary goal of making India a global manufacturing hub by encouraging foreign private companies to manufacture within the country. Defence manufacturing was one of the 25 sectors focused on by the Make in India initiative. Subsequently, a number of initiatives have been taken, one of the major ones being the striking of a defence deal with Russia in December 2015, for the manufacture of the Kamov Ka-226 multi-role helicopter in India. This has been widely seen as the first defence deal to be actually signed under the Make in India campaign.

Today, India stands under a deluge of ToT proposals from a number of developed countries and their firms. Foremost is the US which has offered 17 technologies, with another 24 on the cards, as far back as in October 2015. These do not include four 'pathfinder' projects which were identified by India and the US for co-production of defence products based on comparatively simpler technologies. Besides the US, firms from numerous other developed countries have also offered ToT for a number of defence systems, with some as significant as fighter aircraft and submarines. One of these firms has offered 'robust' and 'no-holdsbarred' ToT, while another has offered 'true' or 'real' ToT with full control over system design and software.

ToT and National Goals

At this juncture, we need to take a step back and deliberate the national goal that ToT activity should be aligned with. Should it be a single-minded thrust of developing superior military strength; or that of achieving strategic autonomy through, as we shall discuss later, the unattainable self-sufficiency, aka autarky; or maybe industrial growth and economic development; or perhaps a combination of them? The variables are numerous and this can be debated endlessly. An achievable combination of these, which is in keeping with India's industrial and security policy, can be best worded as 'self-reliance in production of competitive defence technologies'.

Self-reliance in competitive defence technology has been described by late K. Subrahmanyam, the Convener, National Security Advisory Board, in the year 2000, when he compared self-sufficiency and self-reliance. He described self-sufficiency as the in-house production of everything that is needed by the armed forces, a state which he averred was impractical for a

developing nation possessing limited resources. In a more generic sense, his stand is supported by Ron Matthews' view that 'though self sufficiency may be a country's proclaimed goal, it is invariably economically infeasible', to which he adds the example of the technology sharing within North Atlantic Treaty Organization (NATO) countries. A further strengthening of this view comes from the examination of the import of defence systems by various countries today. Records indicate that there is, in fact, no country, developing or developed, which does not import some amount of defence equipment. In the year 2015, for instance, in the top developed countries, the US imported arms worth US$ 565 million, while Russia imported an equivalent of US$ 201 million.

On the other hand, self-reliance, was defined by K. Subrahmanyam, as the equipping of the armed forces with a range of weapons and equipment either from foreign or indigenous sources, but with the condition that the operational exploitation and maintenance of the foreign equipment must not be held hostage under any circumstances.

Another definition of self-reliance can be obtained indirectly from the objectives set by a self-reliance review committee headed by Dr A.P.J. Abdul Kalam in 1992. The committee, which defined the self-reliance index (SRI) as the percentage share of the indigenous content in the total procurement expenditure, suggested the objective of achieving an SRI of 70 per cent from the existing 30 per cent over a 10-year period ending in 2005. This target has not been achieved till today and the Indian government, through the DPP 2016, now stipulates a minimum 30 per cent in the 'Buy Indian' and 'Make' categories and 50 per cent in the 'Buy and Make (Indian)' category. From all these indicators, being self-reliant can be taken to mean the country's ability to manufacture a significant portion of the components of defence systems.

So does ToT enable self-reliance? There is no doubt that ToT provides the capability of manufacturing a significant portion within the country, thus meeting the SRI objective. It is also well known that ToT contracts of the past have invariably included the requirements for operation and maintenance, thus meeting K. Subrahmanyam's perspective. However, having stated that, the probability that proprietary spare parts may not be available over the entire life of the equipment does exist, as has been unfortunately experienced by India with Soviet-origin equipment after the unexpected collapse of the USSR. It may be worth noting that this risk is not immune to mitigation and measures such as lifetime buys of spares or early development of import substitutes can be greatly effective in doing so.

A national goal higher than self-reliance is defence technology leadership, where Indian agencies achieve the capabilities of making breakthroughs in fundamental research in science, and then convert them through design, development and production into leading-edge defence technology weapons and defence systems. Technology leadership in even a few fields can greatly accelerate the development of leadingedge weapon systems through collaborative arrangements with foreign research and development (R&D) agencies willing to share, in return, some of their

complementing technologies. Can ToT possibly help India achieve such a goal? Though apparently improbable, this article attempts to explore the nuances to arrive at an answer.

Defining ToT

ToT, as a phrase by itself, can generate widely differing perspectives from a recipient country's perspective. For the layperson, not acquainted with these matters, it can appear to be a transfer of information and hardware which allows the buyer to independently build up on for future upgrades or even superior designs. If this had been the case, India and many other countries would have been self-sufficient in fighter aircraft, helicopters, armoured tanks, artillery guns and numerous other systems which have been licence manufactured through ToT. Others may assume that there is nothing to gain from ToT since it only increases dependence on other nations. Yet another view is that ToT is a half measure, not capable of creating design and development capabilities. Further compounding the confusion is, as stated by Encyclopedia.com, the difficulty in defining the exact nature of this activity, partly because the term has many different connotations.

As per the United Nations Conference on Trade and Development (UNCTAD) document, Transfer of Technology, technology is the knowledge that goes into the creation and provision of a product or service. Sakti and Indrani Mukherjee define 'technology' as 'an organised knowledge of production', and further describe it as 'a set of instruments or tools, materials, know-how and abilities' which may be 'bought and sold as capital goods, human labour and information'.

In the international defence environment, there are references to 'technology' being specific information necessary for the 'development', 'production' or 'use' of a product. This information could be in the form of technical data or technical assistance. 'Technical data' could take forms such as written plans, product diagrams, models, blueprints, formulae, tables and specifications as well as instruction manuals written or recorded on other media or devices such as disks, tape and read-only memories.

In the Indian defence environment, there are references to technology being the complete expertise (engineering–manufacturing documentation to enable fabrication, assembly and test of item) or expertise to maintain the system in service (called Maintenance ToT), while another relates to it as the process of LM. Yet another (this by the DRDO) quotes the National Academy of Engineering (India) as defining it as: 'including all the infrastructure necessary for designing, manufacture and repair of technological artifacts—engineering know-how, manufacturing expertise and various technical skills—all are equally important part of technology'. The Indian DPP states that ToT (when contracted) shall be:

comprehensive, covering all aspects of design, manufacturing know-how and detailed technical information which will enable the Production Agency to manufacture, assemble, integrate, test, install and commission, use, repair, overhaul, support and maintain the license product. Design data shall include the details that are needed to give design disposition during production on deviation/ concession; modify/upgrade the licence product and substitute parts and systems of the licence product as required by the certifying agency and the production agency.

From these definitions, two distinct aspects of technology, in the context of ToT, come to the fore. One aspect covers its components such as knowledge, skill, expertise, know-how, methods, organisational capacity and infrastructure; and the other specifies the capability that it delivers, that is, development/creation of the product/manufacture/use/ maintain/repair/overhaul, etc.

A closer examination of the first aspect, that is, the components, reveals three distinct categories: technical data or information; capital goods or infrastructure; and technical skills and abilities, each with their own nuances of transfer. Technical data or information can be transported through paper documents or digital media and pose no problems for effective transfer or absorption, unless they require translation. The second, capital goods or infrastructure, requires transportation by different modes and matching resources such as industrial power and water. The third category, technical skills and abilities, which can only be carried, transferred and absorbed by humans, is a little more challenging as regards to its transfer. Widely differing technical capabilities between the seller's reps and the buyer's reps, coupled with differing work cultures and languages, make the transfer and effective absorption of this category not an easy task. It is also interesting to note that technical skills such as know-how are also considered industrial (now intellectual) property (IP), along with technical data and information, and these are treated at par with property such as capital goods or machinery.

The second aspect of ToT, that is, the capability that it delivers, also needs further deliberation. Going by this aspect, we have definitions of two types of ToT which are already in common use. One is ToT for manufacture, which is generally referred to as ToT, and the second is ToT for maintenance/repair/overhaul (MRO), commonly referred to as MToT. Are there any other variants which exist? The definitions given earlier mention that ToT is implemented to enable the 'use' of the product. Should ToT also not cover an 'Operate ToT' or OToT, especially since such contracts for 'operate and maintain' have been executed in the past? There are also MToT variants with differing depths for MRO of the product. For the sake of comprehensiveness, it is worthwhile covering all the variants.

The definitions of technology, discussed earlier, also include a 'development' capability and a 'design' component. Does that mean that ToT could also empower the technology recipient to design and develop its own products? A glance at the general nature of ToT arrangements discussed in various literature and the media would indicate to the contrary. No such factual instances of ToT with 'design' enabling 'product development' have been referred to or reported

in the Indian defence environment, or for that matter, anywhere in the world. Yes, the passage of the DPP, which describes design data as conferring the 'disposition to deviate from specifications or modify or upgrade a part or substitute the part', does aspire for such a transfer but in a very limited sense, and more as a measure to overcome potential stoppages in manufacturing than for the development of new products.

Despite its apparent non-existence, it may be worthwhile defining such a transfer as 'Design and Development ToT' (D&D ToT), if only to refer to a transfer that is strongly aspired for by technology seekers. In the case of the DPP, the additional capability that is requested for may be termed as a ToT with capability for limited design deviations/ modification/upgrade, which we could abbreviate as DToT (Limited).

So, a holistic view of ToT and its variants can be drawn up as in Table 1. The variants are listed in increasing order of capabilities conferred and depth of technology transferred. It has been the general observation that contracts for each level of ToT also, invariably, include the previous level. For example, an MToT would automatically involve an OToT, or a PToT would automatically involve an OToT and an MToT. The 'deeper' the ToT, the more is the capability (and hence selfreliance) conferred.

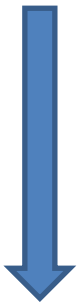
Capability Desired	ToT Needed	
Operate	OToT	
Maintain	MToT (M)	
Repair	MToT (MR)	
Overhaul	MToT (MRO)	
Produce/manufacture/assemble/integrate	PToT	
Minor design deviation/modification	DToT (Limited)	
Upgrade/develop variants/develop alternate products	D&D ToT	Deeper

Table 1: Assigning of ToT Variant Definitions

Intellectual Property (IP) Assignments and Licences

How are these technology transfers actually implemented? Since 'technology' exists in the form of property—physical and intellectual— ToT essentially translates into either an assignment of the property or licensing of the use of these properties by the technology holder to the technology recipient. An IP assignment is a permanent transfer of ownership of an IP, such as a patent, trademark, copyright or knowhow, from one party (the assignor) to another party (the assignee). The assignee thus becomes the new owner of the IP. A licence agreement, on the other hand, is a contract under which the holder of the IP (licensor) grants permission to another party (licensee)

for the use of its IP, within the limits set by the provisions of the contract. Assignment and licensing are considered the primary forms of 'commercialisation' of technology.

'Know-Hows' and 'Know-Whys'

Achieving or acquiring the capability to design and develop its own systems is undoubtedly the ultimate goal for any country. What exactly are the components of knowledge which enable such a capability? And why is it not possible to acquire it through the apparently non-existent D&D ToT? The answer can be discerned from a close examination of the difference in D&D ToT and PToT. Manufacturing, enabled by PToT, primarily requires 'know-how', which can be defined as the practical knowledge on how to accomplish something. The knowledge of 'how' to fabricate the concerned parts, 'how' to test them, 'how' to assemble the parts and 'how' to inspect and test them as an integrated whole are all elements of know-how required for production. In some cases, additional knowledge is provided in order to know 'how' to rectify or offset deviations in quality of the parts and 'how' to modify the system keeping within the specified limits. What this know- 'how' does not include, however, is the knowledge required to carry out major modifications, or upgrades or manufacture future, more capable versions of the product. This additional knowledge which has been referred to as the 'know-whys' is, understandably so, not divulged by the technology seller simply because, by doing so, the technology recipient acquires the knowledge to design and build products which could compete with the original firm. Development of military systems necessitates an immense amount of investment in terms of money, time and resources. Why then would a developing firm or country fritter this investment away without securing the maximum returns possible?

A little more insight on what is meant by 'know-whys' is in order here. Let us take the simple example of a helicopter blade. The knowhow needed to manufacture it would include the method to arrive at a specified metallurgical composition and the specified process of moulding or forging this composition into a desired shape, dimension and strength. This combination of the right composition, process, shape and strength would ensure the blade provides a certain amount of thrust at a certain speed of rotation without it deforming or breaking within a certain amount of usage. Possible compositions could number upto many hundreds, and so also would the types of processes, shapes and strengths. The developing firm would probably have taken many hundreds of iterative experiments and trials using extremely expensive laboratory instruments to meticulously document and arrive at a conclusion as to 'why' a particular combination of composition, process and shape is optimal. If this documented knowledge were to be obtained by the recipient firm, it would empower the firm to further improve the blade without depending on any inputs from the developer. In many cases, the knowledge acquired during development may not be fully documented, resulting in a component of knowledge known only to the developing scientist. This component, referred to as 'tacit' or 'implicit' knowledge, is acquired from

'learning by doing' patiently over many years and is generally difficult to acquire through formal ToT.

Does the non-existence of D&D ToT mean that no transfers occur during and immediately after the R&D stage? Literature published in the field indicate that this is not necessarily true. Today, the proliferation of research activities among the small and even micro enterprises throws up situations where a company does not have the means to undertake commercialisation or prefers to receive a once-off lump sum payment for the innovative technology that they have developed. In collaborative research too, situations arise where a transfer of IP ownership from one of the collaborative research partners to another is effected to allow the partner to go ahead alone. Since technology also matures in stages, as is depicted in the Technology Readiness Levels concept of the US Department of Defense (DoD), it is quite possible that small research firms may not be in a position to take spin-off technologies to maturity, and therefore decide to assign (permanently transfer) their rights to another firm in return for suitable remuneration.

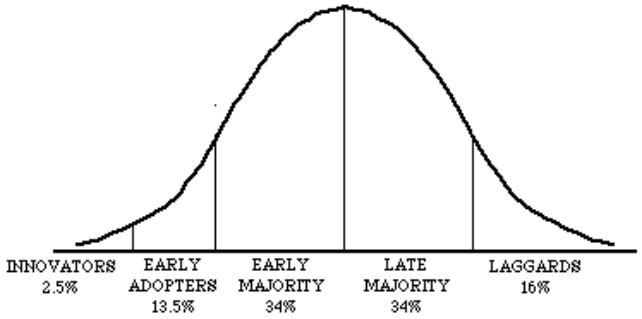


Figure 1: Everett Roger's Bell Curve for Innovation Adoption

Technology Adoption Timeframe

Technologies go through a life cycle which initially starts as a phenomenon being discovered in a laboratory through fundamental or basic research. The concept of utilising this phenomenon for a specific purpose is then proven through applied research. If successful, the concept is developed into a prototype and tried in real-life conditions. If successful, it is then productionised. Even after production, technologies are continually improved upon, increasing their utility and reliability. As a new technology appears on the horizon, the current technology is exploited fully for maximum returns and then retired to give way for the new one. The stage at which a technology is adopted is critical to its economic exploitation. Adopting a technology at a very nascent stage when the technology is not fully ready may throw up teething problems in manufacture and poor reliability of the product, while its adoption at a very late stage will result in difficulties in maintaining it due to obsolescence issues. Figure 1 displays Everett Roger's bell curve which indicates the relative population of the innovation or product adopted at various

stages of its life cycle. To fully exploit the technology while it has the competitive edge would mean targeting the early adopters or at least, early majority categories.

ToT from the Seller's Perspective

In the context of defence technology where the competitive edge over an adversary is crucial, the importance of acquiring a 'new' technology which provides the critical edge is immense. Countries which have developed cutting-edge technologies are therefore reluctant to participate in deeper forms of ToT immediately, no matter the price offered. However, they may be willing to do so at a later stage when they have developed a newer replacement. Commercially too, advanced or newer technologies would cost more and recipients may have to understand this during their acquisition cycles. Most developers will naturally attempt to squeeze the most out of their developed technologies and will be unwilling to assign their full and unfettered rights until the technology holds no promise for further development.

The primary benefit of ToT to technology sellers is the revenue through which they can recover their R&D costs and build profits. Besides this, some companies may use ToT to create an industry standard such as the global system for mobile communications (GSM) and codedivision multiple access (CDMA) for mobile phones. An establishment of such a standard would increase their revenues, and also provide them a platform to build on. Some companies may wish to partner with a firm that has the resources or complementary assets needed to commercialise their technology. Governments use ToT as an instrument in building strategic relations with another country, as is seen in numerous examples around the world. In doing so, they also provide a fillip to their own defence industries which supply proprietary parts and machinery for maintenance, repair and overhaul. Once the buyer countries become dependent, the seller country acquires the ability to apply pressure through linkage or leverage on the buyer country to accede to more agreeable policies.

The Benefits to the Recipient

There is no doubt that ToT has some distinct benefits for the recipient country. Besides the primary benefit of meeting the particular need in a cheaper, faster and easier method than developing the product from scratch, ToT has many side benefits.

First, the acquisition of technology in physical form leads to an awareness of its capabilities in the recipient country. This 'technology diffusion' provides a fillip to the overall technology awareness in the country and motivates people in various sectors to strive for higher, more productive means. Second, new technology for manufacture brings in new industrial machines

and processes, and thus helps to modernise the production system. Some processes may require particular skills which are acquired by the workforce of the recipient country.

Third, production lines invariably need subsidiary firms to manufacture ancillary parts and therefore, it promotes industrial growth and economic development. Fourth, increased production would increase employment and tax revenues. In cases where there is a potential for export, it could bring in precious foreign exchange and improve the country's trade deficit. Fifth, foreign technology invariably requires some level of adaption to match the local conditions. This adaption, enabled by the absorption of the new technology, can build up innovation and technological progress within the recipient country.

The Costs

The flip side is that the price of ToT is often challenged as being exorbitant since firms selling technology have been known to take advantage of the oligopolistic nature of the imperfect high-technology market. Besides the basic cost (which is itself difficult to value accurately and can be easily inflated), technology suppliers have been known to extract excessive returns through a multitude of measures listed next:

1. High royalties and fees for licensing subsequent batches of production cause a heavy burden.
2. Costs for right to use the trademarks.
3. Costs through artificially hiked up prices of parts from intracompany sales.
4. Costs for profits capitalised in the acquisition of shares in the receiving company.
5. Costs for some parts of the profit of fully owned subsidiaries which have no special provision to pay for technology transfer.
6. Costs due to overpricing of capital goods, that is, industrial machines and equipments.

One would assume that ToT to a less developed country with significantly cheaper labour and infrastructure, such as India, would enable manufacture of products at a cheaper price than that supplied directly by the foreign seller firm. This assumption, unfortunately, is not always true. Ron Matthews cites the examples of Gnat fighters which were produced at a unit cost of US$ 2.5 million, which was in excess of the import price, and of the Anglo-French Jaguar aircraft which, in 1980, was estimated to be produced at Rs 200 million which was double that of buying the plane from Britain. Exact reasons for this increased price remain elusive, but an intelligent guess would assign the increase to the inflated costs of licences or royalties, inefficiencies of manufacturing at low scales, coupled with inefficiencies due to suboptimal management, work culture and workforce skills. The situation today remains much the same with foreign firms indicating higher prices of the Indian licence manufacture product and that larger localisation will increase prices.

Restrictive Trade Practices and Restraints

Besides imposing apparently unreasonable costs, suppliers also attempt to guard the business angle of their technology by forcing the recipient to agree to numerous trade restrictions and restraints. While some are considered acceptable, many have been termed unreasonable or monopolistic/anti-competitive, and have been sought to be banned or restricted through appropriate legislations in the buyer countries as well as the UNCTAD Code of Conduct on ToT, with limited success. A glance at the list of restrictions that have been known to be imposed is enlightening.

1. Restrictions on field of use, volume and territory over inordinately extended durations of time.
2. Restrictions on right of the recipient to sell the product of the ToT to persons other than those designated by the seller.
3. Restrictions on R&D in the field. Since this could very well fall under anti-competition practices, it is now being applied as restrictions on the right to any improvement, modification or enhancement of the know-how, and also restrictions to participate in the development or manufacture of a similar product or create derivative work based on the licenced equipment.
4. Tying, that is, imposing on the technology recipient the obligation to purchase, apart from the technology wanted, additional inputs such as raw materials and machines.
5. Price fixing, that is, imposing on the technology recipient the prices fixed by the technology seller.
6. Restrictions after expiration of industrial/intellectual property rights.
7. Restrictions on the technology recipient to challenge the validity of the rights conferred by the ToT contract.
8. Grant-back provisions which impose on the technology recipient an obligation to transfer back to the seller any improvements, inventions, additional experience, etc., in the working of the technology transferred. These are now being replaced with clauses prohibiting modification, disassembly and reverse engineering.
9. Export restrictions or export permission for specified countries only, higher royalties for exported products, etc.

A close look at the restrictions against the opportunities that ToT may offer for improving capabilities in indigenous design and development reveals that the recipient's hands are well and truly tied. There is no freedom whatsoever for the recipient to channelise the know-how that has been obtained either for upgrading the product or for the development of other products. The best that can be expected are minor innovations through stretching the design deviation limits. This too, invariably, depends on the consent of the technology supplier.

In the 1960s and 1970s, India, like many other countries, enforced protective measures against unfair restrictive trade practices through appropriate legislation, though these were marred by numerous weaknesses. One such legislation was the Foreign Exchange Regulation Act (FERA) of 1973, which was revised in 1976 to regulate imports of technology. Some of its important provisions, later strengthened by government guidelines, were: the limiting of royalties; phased payment for technical know-how; freedom of Indian party to sub-licence; no restrictions on exports; and freedom to manufacture items patented in India. Unfortunately, the Act also provided a number of exceptions for sophisticated technology, thereby self-defeating its provisions.

Similarly, the Monopolies and Restrictive Trade Practices (MRTP) Act of 1969 specified eight cases that was exempt from its provisions. The Indian Patents and Designs Act also provided numerous exceptions and thus could not check monopolistic trends in the production and sale of patented articles. Today, these legislations stand superseded to newer laws which have reduced the vulnerabilities that existed. The issue, however, has become increasingly complex due to the growing emphasis on IP protection over the past two decades, which negates to some extent the thrust on reducing anti-competitive practices.

Other Conventional Modes of ToT

Licensed manufacture or PToT, as described in the beginning of this article, has been the predominant mode of technology transfer in the Indian defence sector over the past many decades. It has been mainly facilitated through government to government (G2G) agreements, with the ToT to the state-run OFs and DPSUs. In the last decade, however, many private firm to private firm (P2P) or private firm to state-run agencies (P2S) PToT contracts have been initiated and executed. Private firms are, understandably, cost conscious and are particular that they deliver only as much as has been paid for. Hence, agreements are possibly much more detailed to enable smooth execution.

After PToT, the most common of the conventional modes being linked to ToT is joint ventures (JVs) for co-development and coproduction (JVs CD–CP). As the name suggests, JVs are independent entities formed from the contribution of two or more agencies or companies to achieve common goals. For such an arrangement to be successful, it is necessary that both partners contribute by bringing in complementary technologies, in addition to funding. India has used this arrangement through collaborations with Russia for developing and producing the successful Brahmos missile; and with Israel for the medium-range surface-to-air missile system (MRSAM), which has been recently announced as successful. On the positive side, it has been reported that 70 per cent of the MRSAM system will be indigenous when productionised. However, there are also unverified and possibly biased reports that the Defence Research and

Development Organisation (DRDO) contribution was minimal, limited to making a few changes in the versions for the navy and the army.

Irrespective of whether there was any contribution by Indian agencies, what is strange is that in both the Brahmos and MRSAM projects no mention has been made on what technology has actually been transferred. From working together, India should have gained the know-whys in system design as well as product development and production process development that Russia and Israel employ. Through working together, a fair amount of knowledge on the Russian and Israeli portions of the systems may have been gleaned. But have the know-whys or the know-hows of developing and manufacturing those portions been obtained through mutual agreement and consent? A significant aspect to note is that JVs actually allow the owner to maintain a tighter control on its technology. That is why owners are willing to use relatively newer technology in JVs as compared to that in LM. Another aspect is that this arrangement leads to joint intellectual property rights (IPRs) as well as shared international market space and, therefore, the technology cannot be exploited and exported with the freedom that pure indigenous development facilitates, though it is comparable with LM that is limited by similar restrictions.

From the self-reliance perspective, therefore, JVs CD–CP do not appear to be overly beneficial. The fact is that India or Indian firms will remain dependent on the foreign partners for their portion of the system until an indigenous version is developed. The development of the indigenous version too is very likely to be restricted by contractual clauses inserted by the foreign firm so as to protect its business interests. So, while the average LM would lead to dependence of say 30 per cent, which can be subsequently reduced through import substitution, a JV could involve a dependence of 50 per cent, which may be more difficult to reduce due to the relatively newer technology employed. For technology competence, however, it can offer some benefits in terms of exposure to world standards of design and development processes,as well as world standard products. But from the cost effectiveness angle, since development projects in general are prone to risks of delays and sometimes even failures, this arrangement will invariably turn out significantly more expensive than a PToT one.

JVs are also used for co-production only. One such example is Lockheed Martin's JV with the Turkish Air Industries (TAI), a stateowned company, for the production of F-16 aircraft in the 1980s, which resulted in successful production of a total of 308 aircraft over a period of around 12 years. The share ownership was as follows: TAI had the major share with 49 per cent; Lockheed Martin had 42 per cent; General Electric (GE) had 7 per cent and the remaining was held by two other firms. A total investment of $137 million was made, with $70 million from Turkish partners and $67 million from the US partners, which was later supplemented by the latter with another $100 million. Lockheed Martin provided three experienced directors for five years and the general manager for 14 years. From the experience gained from building 80 per cent of the F-16 aircraft, TAI began branching out into other areas to include: parts of the transport aircraft CN-235 and A400M; modifications of Boeing 737s into an airborne early

warning aircraft; and parts of helicopters Agusta Mangusta T-29 and Sikorsky T-70 Blackhawk. The TAI also developed a modification centre where they upgraded aircraft such as the C-130s, F-4s, T-38s and F-16s. Lockheed Martin claims that the company is now developing indigenously designed unmanned aerial vehicles, basic trainer aircraft and even a T-FX fifthgeneration fighter aircraft. Whether these projects will be successful however, will have to be seen.

Interestingly, after 20 years, the Turkish government bought the shares of the US partners and TAI is now wholly held by government entities. Lockheed Martin claims that it remains closely associated with TAI and values its partnership as a major supplier for the next-generation platform.

Lockheed Martin also claims it has had similar success with other countries in the world, such as Belgium, the Netherlands and South Korea. With the latter, it has co-developed the new T-50 and F/A-50 aircraft for the global marketplace and is also helping develop Korea's KF-X next-generation fighter. The contract with the Korean companies is purported to have been a 'strategic alliance' or 'partnership/teaming model' with clearly defined workshare, rather than a JV. The partnership entailed a much higher investment by the Korean companies but included greater freedom, such as a clause allowing the Korean companies to buy out the IPR at a later stage.

Lockheed Martin, it appears, has also helped the Japanese with the development of the F-2 fighter programme. This was a case where the Japanese paid up front for the US firm to impart capabilities of designing, developing and manufacturing their own aircraft – an arrangement which appears to be very rare. Though the amount paid is not known, it is likely to have been exorbitantly high, clearly unaffordable for developing countries.

Though only Lockheed Martin's experience has been described here, there are probably numerous other such success stories in the defence world. Saab, Sweden has recently announced its ToT project with Brazil for the Gripen fighter aircraft, covering the production, maintenance and development of additional features and a new variant for Brazil. The arrangement appears to be following a similar pattern of first focussing on co-production, then development of customised features and finally veering towards full system development.

From the broad insights received on these JVs CP, it appears that the mode has potential to build the know-hows of manufacturing followed by some amount of know-whys, which are ordinarily not received in the LM mode. From the self-reliance perspective, the initial stages of generally undesired and apprehensively viewed majority control by the foreign partner seem to get well compensated by the long-term benefit of appreciable autonomy through buying off foreign shares or IPR. As for technology competence, partnering with global leaders ensures a respectable level.

The strategic alliance/teaming arrangement for workshare also appears useful especially if some amount of capability already exists within the country, as is the case with India. It is, however,

unlikely that foreign partners will be open to eventually assigning/transferring the IPR of their part of the system, though they may be open to licensing them for manufacture. Here too, self-reliance and technology competence appear achievable on similar grounds as that of the JV CP, though the quantum of technology transfer is likely to be much lower.

Encouraging foreign direct investment (FDI) is a common policy used by governments to facilitate technology transfer into JVs with local firms. These JVs could be of the non-equity or equity form. The non-equity form is essentially a strategic alliance where the foreign investor offers the technology whose value makes up part or whole of his investment, while the local partner offers the infrastructure, workforce, management, etc. The foreign investor becomes the technology partner/supplier, while the local firm absorbs it. The technology could be transferred in a number of ways, such as the LM mode or through contract manufacturing/subcontracting using documents for build to print (B2P), build to design (B2D) or build to specifications (B2S). The FDI and technology can also be channelled in a similar manner into JVs where the equity is shared.

In a B2P contract, the foreign firm provides the technical specifications, engineering documents and manufacturing process documents. The manufacturing process documents would include manufacturing drawings, detailed work instructions/manufacturing practices, quality requirements, detailed specifications of the product at intermediate stages, test methods and acceptance/rejection criteria, while the know-how would cover procedures taught through training sessions and tacit knowledge embodied in the technical consultants of the foreign firm. The local firm executes the task strictly as per the above documents/instructions and using material or parts from sources recommended by the foreign firm. Unfortunately, a few proprietary components of the seller firm are invariably required, thus leading to a dependence. Another disadvantage is that the arrangement provides the know-hows of the manufacture process but not the know-whys. The B2P contracts are usually considered a ToT, so foreign firms need the approval of their government or even international export control agencies, if applicable.

In a B2D contract, the foreign firm provides the technical specifications and engineering documents. The engineering documents cover the drawings, acceptable tolerances, material compositions, surface finish required or, in the case of electronic modules, the circuit diagrams, net list showing connections between all components of printed circuit board (PCB) and Gerber diagram showing layout of components on PCB. The local firm is now required to develop or use its own process to manufacture the part. The advantage here is that an indigenously available manufacturing process technology is being utilised, thereby avoiding the cost of purchasing a licence for a new one or the royalties for using it repeatedly. The product design, however, is considered intellectual property (IP) and royalties will need to be paid for its use.

The B2S contract is, strictly speaking, not a ToT. However, it has been described here because these contracts are invariably combined with B2P and B2D ones to produce the different parts of

a system under PToT. The foreign firm provides the specifications which may include the detailed dimensions, acceptable clearances, performance characteristics, reliability, etc., of the product. It is now left to the local firm to design, develop, manufacture and supply the product. For successfully achieving this, the phases of prototyping, user trials, evaluation, etc., may be required and will therefore take considerably more time, effort and money as compared to B2P or B2D. However, since the B2S mode is not a ToT, it doesn't require export permissions of the foreign government or international export control regimes. Also, since the local firm has developed the product on its own, it holds the IP rights and the knowwhys, and is therefore free, as well as capable, of exploiting them for producing product upgrades or variants, or for that matter, applying the technology for other purposes.

A prevalent view is that forming of JVs, whether for co-development and/or co-production or for sourcing technology through FDI, is a more complex, risky and time-consuming task than executing LM and is hence recommended only in cases where the complementary capacities, infrastructure, technology or capability available with the partners requires engagement for a longer term. However, when such arrangements fit well with a mutual goal of profitability and acquiring a global market, the results can be extremely rewarding, as can be seen in the case of Lockheed Martin's JV with the TAI.

The level of investment and control of the partners in the running of the JV is a critical issue for foreign technology seller firms. Firms holding proprietary rights over cutting-edge and niche technologies, which have little or no competition in the world, may insist on a wholly owned subsidiary, while those offering a little older technology may be satisfied with a 51 per cent majority share of investment. The majority share enables the foreign firm to keep a tighter control on its technology and thereby prevent it from leaking out to competitors. A foreign firm representative has postulated an interesting rule—where firm and sufficiently high orders are assured by the host government for a period of 20 years, such as that for a strategic partner, a 49 per cent share or less will do. However, where these are not assured, and the firm needs to compete in a global market, a majority share is a must.

Another facilitator that is being pursued in India for the acquisition of technology is 'defence offsets'. Here, a foreign OEM, to whom a large contract for the manufacture and supply of systems has been awarded, is obligated, in return, to use any of six avenues for benefiting India's defence and allied industry. Out of these six, four pertain to technology transfer in their different modes. This is in keeping with the worldwide trend of using offsets as a potential source of ToT. The transfer could be by subcontracting or PToT, through direct contracts or JVs with private firms (non-equity or equity), or PToT with government agencies and finally, acquisition of critical technologies by Indian DRDO. For enabling the last option (which has not been analysed so far), the DPP provides a list of 20 critical technologies, such as MEMS-based sensors, actuators, radio frequency (RF) devices, focal plane arrays, and nanotechnology-based sensors and displays.

Though the areas of critical technology have been specified, the DPP makes no mention of whether the technology desired is to be provided on licence or permanent assignment, for manufacturing or designing/ developing a product or process. Going by inputs of reliable sources, it appears that the intention was and is to acquire the know-whys, in addition to the know-hows, of manufacturing products with that technology. It is also broadly known that though eight proposals under this avenue have been received, none of them have been accepted due to the exorbitant prices quoted, which are to the tune of a hundred times that of the manufacturing technology. It may reasonably be concluded, therefore, that this avenue is not likely to enable useful transfers in the future, unless the DPP offers much higher offset credits for such proposals.

Widening the Scope

So far, we have identified and analysed the conventional forms of technology transfer. But are there possibilities for more avenues—avenues which can provide newer technology thereby enabling the closing of the gap with the advanced countries? Let us widen the ToT umbrella, where 'technology' does not merely cover the knowledge of use/operation, maintenance, repair, overhaul or production (or manufacture) of a defence system, as has been mentioned in numerous sources, but all the knowledge that is generated and transferred in the path to realisation of the defence system. Such a path can be broadly divided into six steps:

(1) discovery of a new material or phenomena;
(2) development of its application and prototyping;
(3) development of the process for manufacturing the part;
(4) mass manufacturing of the part;
(5) designing systems and integrating the developed parts (and others)into them; and
(6) productionising the system.

A pictorial view is provided in Figure 1. The figure broadly reflects the environment in the US and most developed Western countries where fundamental research at universities is funded by government, corporates and non-profit organisations. Even though some research in universities and non-profit organisations are government funded, the creators in the universities can control the use of the invention by a one-time payment for a licence and committing themselves to certain conditions. These licences can be used by R&D agencies to develop new, useful and non-obvious products which can be patented to prevent imitation and secure monetary returns.

Figure 1 depicts how 'technology' evolves and is vertically transferred downstream from one developer to one or many recipients. Each transfer of new technology invariably comes with patents/licences to prevent imitation as well as to channel back income from royalties to the

creators. Some steps may use unpatented, established technology along with new ones to deliver its product.

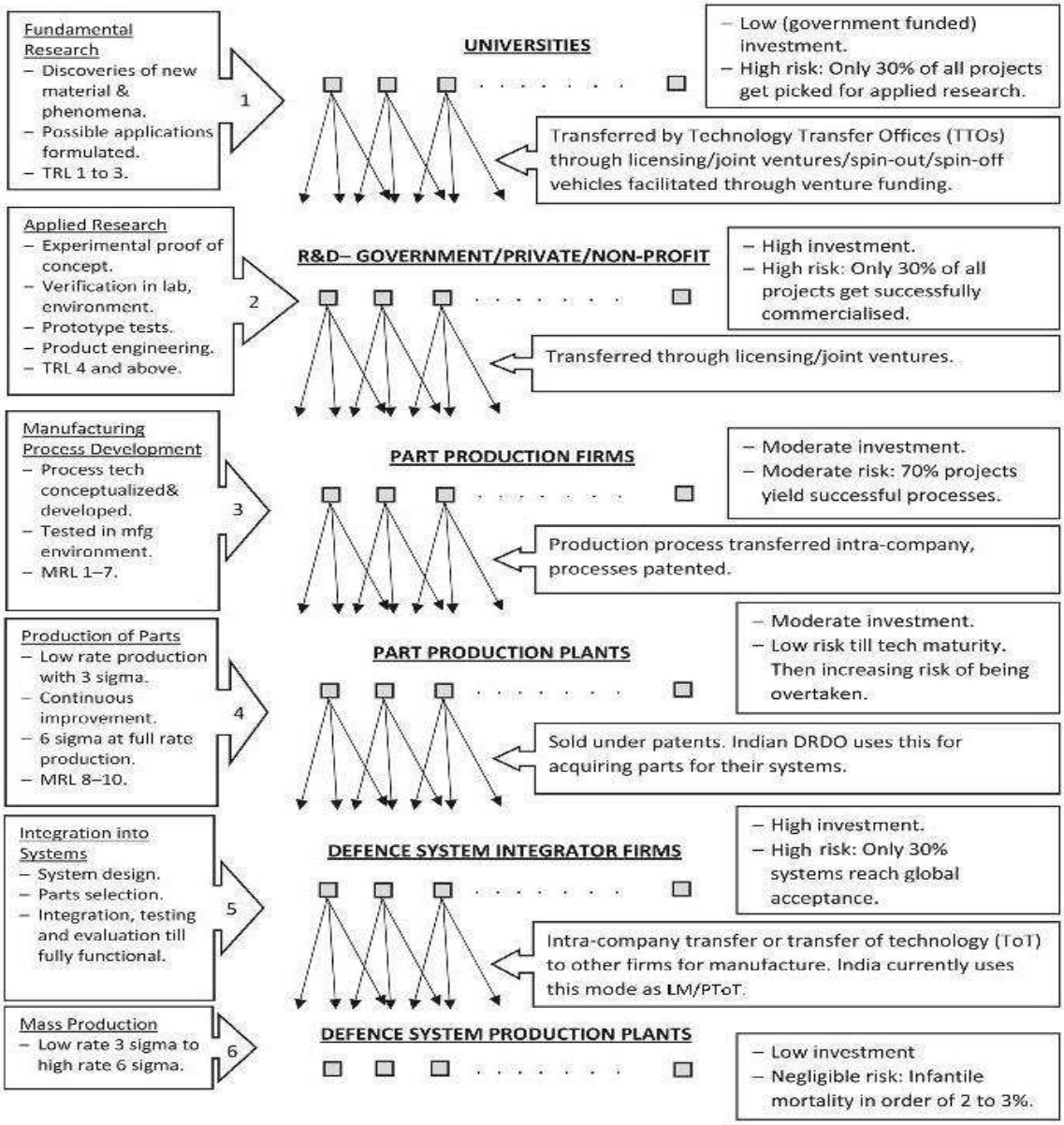


Figure I Technology Movement till System Manufacture

Each step depicted, less steps 4 and 6, entails the use of know-hows to develop the product of that step, and in the process, learns to 'know why' the product needs to have, say, certain dimensions or compositions of material. To amplify this point, one can see that in step 1, one would need to know 'how' to conduct the research. During the research, an understanding of 'why' the phenomena will work only in certain conditions will develop. In step 2, one would

need to know ‘how’ to develop the technology and design the product. In the process of doing so, it will be learnt ‘why’ specific dimensions or composition of material are necessary to achieve the performance desired. In step 3, one would need to know ‘how’ to develop the manufacturing technology, thereby generating know-whys on the processes, settings and specifications of each manufacturing activity. In step 5, one would need to know ‘how’ to design a system. Thereby an insight into ‘why’ a particular dimension or composition or configuration is necessary to achieve a performance characteristic will be developed. However, in steps 4 and 6, only a limited amount of know-whys are generated, though these too have their significance, such as those generated while fine-tuning the production process to reduce the incidences of defects to a minimum level such as 6 sigma.

From the figure, it can also be seen that each step involves an investment and an uncertainty of success (or a risk of failure). Some steps, such as step 1, could require low funding (generally government funded) but entail high risk, while step 3 entails moderate funding with moderate risk. In the R&D stage at step 2, due to the need for high investment and the presence of high risk, small and medium enterprises (SMEs) may turn to sharing the incipient technology in a quasi-licensing framework enabled through venture capitalists (VCs), while large corporates may opt for joint R&D through strategic alliances or partnerships. After the R&D stage, when business gains of successful projects start to neutralise development costs, the ownership of the technology could change either to stockholders of an initial public offering (IPO) or one of the partners of a strategic alliance. These owners typically use strong patents to extend the life of the technology and do not share it till competing technologies start eating into its share of the market. Sharing could be either through licensing or participatory exploitation in a JV, especially with firms of developing countries where the technology is still unmatched. The latter option is considered superior due to the greater control of the technology owner and dual income through investments as well as royalties.

At step 3, the development of the mass manufacturing process of a developed and patented part could be executed by intermediary firms or manufacturing firms with process development capabilities. These processes can also be patented to prevent illegal imitation and for obtaining monetary returns. Sometimes development of manufacturing processes can, however, take extremely long and necessitate large investments.

At step 4, production firms obtain a licence for use of the process to manufacture, paying either a fixed amount or a royalty on each product produced. These parts are then sold under legal agreements protecting the patents from violation by copying, reverse engineering, imitation, etc.

A similar framework for the system development exists at step 5 where the process of integrating the system as well as the developed system itself can be patented. At this stage, the integrator firm or OEM can either sell the finished system from its production plant or sell the production technology to other production plants. The latter is the activity we have defined as PToT.

The technology in PToT is clearly a finely finished product, with meticulous documentation for all aspects of integration, testing and quality assurance. When delivered to new firms, it is also invariably supplemented with the technology for operation, maintenance, repair and overhaul (if applicable). The manufacture processes are also matured with many contributory factors for failures being removed over a period of time. Little is left to be worked out by the recipient firm, which can employ technically less knowledgeable, less skilled and therefore cheaper labour. Hence, its suitability for less developed countries. In this arrangement, production can be executed with very little involvement of the transferor and with greater freedom to the recipient. However, in being so, it also holds a higher risk (to the seller) for the technology to be compromised, and is therefore used predominantly for older technology.

Opportunities for India?

Now that we have a broad understanding of the evolution and movement of technology, let us see if we can make use of it in our search for more avenues of ToT. A close look at Figure 1 shows that each step and the transfers after that are actually opportunities available for obtaining technology.

At step 1, cannot India partner with the advanced countries for fundamental research in select fields? True, fundamental research may throw up discoveries or inventions with a wide umbrella of applications from medicine to manufacturing and may not lead to military ones. In such an eventuality, the applications can be used by the respective industry in India. The India–US Science and Technology Forum, which evolved in the year 2000 after many decades of increasing cooperation in the science and technology fields, now has multiple programmes for interaction by students, researchers and entrepreneurs. Such forums exist with other countries too. Can this area of activity not be enhanced to draw more benefits?

After step 1, can DRDO laboratories use transfers of the findings of fundamental research (through licences) to develop products which are patentable? It is very possible that of the competing technologies developed, only some are selected by the foreign government/agencies. Others which hold promise, but will not be utilised, can therefore be procured, possibly at a lower cost. Of course, this may require large investments and entail uncertainties in success. But couldn't this risk be mitigated by distributing the investment in a range of projects? If such transfers cannot be out rightly purchased, can India not fund some of the research projects at step 1 and maybe supplement them with Indian scientists deputed for specific durations for licensing rights? It is known that OEMs such as SAAB, Nexter and Lockheed Martin have sponsored research projects in very niche areas with numerous universities around the world. Then, why can't our DRDO and Indian private giants explore such opportunities in addition to the Indian research that they currently sponsor?

The Indian Department of Science and Technology's Global Innovation and Technology Alliance (GITA) is a potent arrangement where Indian researchers and developers avail opportunities for partnering in research with their counterparts in advanced countries such as the United Kingdom (UK), Canada and Israel. The technologies covered are wide-ranging, from affordable healthcare to smart cities to the Internet of things, MEMS, and strategic electronics in areas such as power and telecommunication. Can similar arrangements not be made for defence or dual-use applications? A step in this direction was taken when the US named India a major defence partner (MDP) and communicated through a joint statement in June 2016: 'India would receive licensefree access to a wide range of dual-use technologies in conjunction with steps that India has committed to take to advance its export control objectives'. Cannot the same arrangement be replicated and utilised for obtaining dual-use technology from other advanced countries?

Or cannot scientists of Indian origin who create inventions in foreign universities assert that the benefits of their research be channelled to their parent country? There is a huge population of Indian scientists in the US and European universities who are probably willing to provide such technology to India. Cannot their work be legally harnessed through intergovernmental agreements providing appropriate clauses in research agreements with them?

Step 2 is actually a consolidation of numerous sub-steps where the technology is developed through technology readiness levels (TRLs)4 and above. Cannot Indian R&D agencies step in to take on such projects or at least a portion of the development such as product engineering for which a large Indian pool is available? The joint R&D and technologysharing agreement with the US initiated as far back as 2006 and the later Defence Trade and Technology Initiative (DTTI) provide such an opportunity for the DRDO. But these are on an extremely small scale. Can such arrangements not be explored in a larger way, and also with other countries? Cannot Indian private giants explore such research arrangements? Again, as in step 1, funding these projects will yield licences for product manufacturing, while co-opting our scientists will provide the know-hows of design and the know-whys of the product.

At step 3, cannot Indian agencies take on the design of the manufacturing process or developing the technology deployed in manufacturing? This step has been reported to provide the highest value addition in the chain. If they are not competent enough as yet, cannot a team of engineers be associated with these projects to gain the know-hows of the development activity and the know-whys of the output? The advanced manufacturing research centres around the world today collaborate with universities, equipment suppliers, manufacturing technology providers, production companies and their supply chains to develop leading manufacturing systems and processes. Cannot some of the DRDO specialists in manufacturing technology join these for improving Indian manufacturing technology and processes?

At step 4, cannot Indian production plants obtain a licence and mass manufacture the products to 6-sigma quality, though this arrangement may be limited to a defined quantity and period? Again, if they cannot, can select engineers not be associated to build capabilities in the field?

At step 5, parts can be purchased under patent protection agreements and integrated into systems. This is an activity which the DRDO, and now the private sector, has been doing for quite some time through JVs for co-development and co-production as covered earlier in this article. However, have the benefits of this arrangement in terms of obtaining world-class know-hows of system design and the know-whys of the developed systems been consolidated? There will always exist a large scope for further capability building in this area. Instead of co-development, can co-opting of brilliant Indian scientists into foreign projects not provide a win-win situation for India and the foreign partner?

All the above options would clearly increase self-reliance since a portion of the development or manufacturing activity is shifted to Indian soil. The latter steps of 5 and 6 are relatively cheaper and easier to achieve especially when a strong base of fundamental and applied research is not available. This is probably the reason why it has been somewhat prevalent in India. For technology leadership, however, it is clear that one would have to move upstream, that is, instead of limiting ourselves to steps 6 and 5, we would need to target the earlier steps. And the higher upstream we go, the higher the possibility of technological superiority, ultimately achieving leadership through pioneering breakthroughs at step 1 or step 2.

It is very likely that many of these options have been attempted by the Ministry of Science and Technology or the DRDO. But if so, what were their outcomes and what were the reasons for their failures? For there are apparently no success stories being reported in the area. These need to be made public, because India's defence industry today includes numerous private giants and over 6,000 micro, small and medium enterprises (MSMEs). All these stand to gain by past experience so as to build ways to tap the development chain of the advanced world.

Unconventional Technology Transfers

With the wider perspective, we realise that all forms of knowledge related to prospective technological products or their evolution can contribute in some way to a country's technological capabilities. The propagation of this knowledge (or technology), which falls outside the conventional forms discussed earlier, can take place through various media and methods. Among these, a significant group of activities come under the category of 'technology diffusion'.

Technology diffusion has been defined as activity which creates an awareness of that technology in the country/region. This could be with or without deliberate intent by the government or the foreign supplier firm. Activity without deliberate intent would include coverage in media such as the Internet, television, newspapers, periodicals, movies and even chat groups. Deliberately

intended activities by the foreign supplier firm could be purchase of inputs, components and services from local firms, requiring the latter to become familiar with the technology. Deliberately intended activities by the host government would include training requirements for local personnel or the compulsory licensing of technology to local firms.

Then there are activities which go beyond technology diffusion and are more focused, deliberate and expensive. These, which we can term as 'technology acquaintance', cover foreign visits by selected persons, technical seminars, journals, published papers, study groups, technology monitors/intelligence, trials and most significantly in respect of defence systems, joint exercises with foreign military forces.

Technology diffusion and acquaintance are significant methods to build awareness of the capabilities of different competing technologies. As such, they contribute effectively to selection in the acquisition process and provide a relatively inexpensive and easily accessible means to initiate activity to acquire and incorporate the technology into own systems. However, whether these activities alone can generate enough knowledge to develop new systems is highly questionable. Many young DRDO scientists have stated that the inputs to their work were the papers published in the public domain as well as seminars in India and abroad. However, if this were the case, there would be no need for technology transfers and the effort and cost for executing them.

Another avenue for transfers is the one enabled through 'flight of human capital'. Scientists and engineers defecting or migrating to new countries, the attracting of scientists back to their home country and the export and re-importing of students are the major ones. This form of technology transfer is not new. In the late nineteenth century, a large number of American students were 'exported to' and 're-imported from' Germany to gain experience in the fast-growing technical fields. A recovering Japan sent its scholars to British universities for obtaining technological experience. China sent large numbers of students abroad after 1978 to gain skills necessary for the country's economic and social development. Then there is the possibility of hiring foreign engineers. Around 2002, the Chinese automotive firm Chery hired the services of an Austrian engineering specialist to transfer the technology of engine design and the know-how to build one. Chery opened its new plant in 2005 with a plan to manufacture 1,50,000 engines to start with. The cost, however, was a huge $370 million, which Chery planned to recover through the economies of scale in the Chinese market.

So, if China can use a foreign engineering specialist and the US and European countries can use Indian scientists for their R&D, what is to stop India using foreign scientists? The exorbitant cost of the background IP (know-hows) that the scientist will bring and that of the IP that he will generate (know-whys and design) is one obstacle. By delivering both these, he, however, terminates his own market value, at least as far as that product is concerned. Hence, though he will deliver the final product, it is unlikely that he will share his complete spectrum of know-hows and know-whys. The second is that it will most probably require the foreign government's

approval under its export control regulations. These regulations are invariably in line with the Wassenaar Arrangement (WA) where even the briefing of a foreign visitor is judged as an intangible ToT, requiring an explicit authorisation. And lastly, in today's collaborative R&D environment, it may take not one but many scientists, possibly networked in alliances, to deliver the goods. Notwithstanding these obstacles, intergovernmental agreements can possibly facilitate such 'scientist exchanges' for mutual benefits.

'Acquiring of foreign factories' and design houses by Indian firms have been reported in the recent past, giving the impression that it will automatically transfer technology to India. However, factories or their machines, by themselves, do not provide technology. As mentioned earlier, they need to be accompanied by technical literature as well as the critical know-how which resides as tacit knowledge in the developers and engineers. Both these are considered IP and need to be purchased through legal agreements. Unfortunately, IP can be exorbitantly expensive especially if it pertains to design and development. Also, since governments in countries such as the US fund many of the fundamental research programmes that lead to design and development of products, transfers to foreign persons or agencies are not permitted without authorisation. Employees of these factories who hold the know-how will also need to be sufficiently motivated to transfer it to workers in a foreign country who will eat up their own jobs!

'Special machinery' or 'software' which enable cutting-edge R&D or production do have significant technology transfer gains, especially if they are accompanied with training and technical consultants. China has been known to procure special machines in excess to their requirement for sub-contracts, so as to learn to use them for their development work. How well this strategy worked is not certain, especially since the machine would have required maintenance and product support. Nevertheless, a trained worker from the sub-contract factory would probably be able to make good use of it for duplicating products.

Lastly, there is a category which uses unethical means such as 'illegal imitation', 'reverse engineering' or 'technology espionage'. PToT contracts invariably prohibit reverse engineering and use of the transferred technology for other purposes, for a specified duration of say 15 years. Beyond the period, reverse engineering can be used for bona fide reasons of modifications for local conditions or indigenisation/import substitution of parts nearing obsolescence. The Chinese method of 'indigenous innovation', as covered earlier, provides a quasi-legal arrangement which involves a way to promote original innovation by reassembling existing (foreign) technologies in different ways to produce new breakthroughs. The Dong Feng-21B anti-ship ballistic missile, which the US strategists have dubbed the 'aircraft carrier killer', is one such example where China reportedly rearranged existing technologies to build the system.

Reverse engineering, however, is a little deeper, in that it aims at decoding and replicating the product or system, which is a clear violation of IP laws prevalent in the world. It is also getting more difficult as an increasing proportion of the composition of defence systems is in the form of

software, making it well-nigh impossible to reverse engineer through studying and replicating the hardware, as has been the approach in the past. Overall, though there have been a few incidences of successful reverse engineering, a general and substantive opinion of the engineering community, other than the fact that it is illegal and not to be encouraged, is that efforts through these modes cannot be relied on and this strategy is fraught with the risk of alienation from dependable sources and friendly countries. And of course, reverse engineering does not provide know-hows and know-whys and therefore will not enable the development of indigenous innovation, design and development capability. Technology espionage is undoubtedly illegal, but not unheard of. In the technology acquisition/introduction/pre-concept stage, the Chinese defence science and technology system employs open-source information collection and espionage activities to overcome the restrictions imposed on transfer of defence-related technology due to the various arms control regimes.

Technology espionage has also been reported in other parts of the world and was probably even state driven during the Cold War period. In the current age of networking and cyber warfare, continuous attempts are made to hack into the systems of adversaries, with the acquisition of their technology being the significant objective. However, the aim here would possibly be to acquire knowledge on their weaknesses and not the entire design and manufacturing process.

Types of Technology Transfer

- *Category I* – Complete Technology Transfer (C-TOT) enables the recipient to carryout fabrication, assembly and test the item provide by OEM (Original Equipment Manufacturer). The latest entrant into the category of capital acquisitions, known as "Buy (Indian Designed, Developed and Manufactured)", will also be covered under this category.

- *Category II* – Items manufactured by the OEM's sub-contractors based on the direction and documentation provided by the OEM, the same documentation is provided by OEM to the recipient, such transfer may also be classified as C-TOT.

- *Category III* –Where the manufacture and the development of the system have been sub-contracted by the OEM to the some other vendor/sub-contractor (may or may not be Indian) based on the procurement drawing and specifications provide by the OEM. In case if the OEM is collaborating with the Vendor for providing maintenance, documentation or training then such transfer should be a "Limited TOT for Maintenance and support ", also called M-TOT.

- *Category IV* – Item sourced by the OEM against his procurement specification as 'fully furnished' may be considered as brought out. OEM will only be able to provide the procurement specification and the source of the supply to ensure availability during the

life cycle of the product. In case OEM, in collaboration with his vendor the document for maintenance and training then such transfer might be categorized as M-TOT.

- *Category V* – Where the OEM is not willing to transfer the technology (having ownership of design and manufacturing document), same shall be classified as the 'proprietary item' such items are generally not included in the scope of TOT[114].

Strategies for the Transfer of Technology

After identifying the category of a ToT contract, the recipient can adopt either of the two defence ToT strategies for the implementation of the ToT contract[115], namely Path strategy and, Engineering strategy.

Path strategy

This strategy comprised of several steps and stages and it depends on country's capacity to decide till which stage it can reach. The following are the steps in this strategy.[116]

i. *Step one - Maintenance & Repair of Transferred Systems*

The recipient develops and gains the skill, knowledge and technical know-how as well as attains the needed infrastructure for gaining ability to repair, maintain & rebuild the foreign product. This is done to attain spinoff benefits like developing domestic skills and creation of employment.

ii. *Step two - Assembly of subsystems from imported components*

This step comprises of the expansion of the manufacturing ability to the recipient of the ToT contract to the assembly stage of the product, this is done under a License Regime by the OEM. Under this step, the recipient is completely dependent on foreign design and information, hence, can't carry their own up gradation, as per their need.

iii. *Step three - Final Production of the concerned equipment and production of its basic components*

This is a crucial step as the recipient develops the capability to manufacture necessary / basic components of the concerned product for which ToT has been entered among the parties, as well as the final assembly of the concerned equipment. Assistance for the establishment, organization

[114] Maj. Gen. Mrinal Suman, "Import of Key technologies: need to revisit policy", *Indian Defence Review*, vol. 26.2 (2011).
[115] Doc. Dr. Aziz AKGÜL, "The Process of Transferring Military Technology to Developing Countries", *available at*: http://www.politics.ankara.edu.tr/dergi/pdf/45/1/technology.pdf (accessed on December 6, 2016).
[116] Dale W. Church, "Countertrade, technology transfer and international defense sales", *Defense Management Journal*, vol. 20 (1984) 10.

and operational facilities for the production of necessary component and final assembly line of the concerned product takes place under this step.

iv. *Step four - Production using Imported design*

At this step/stage, the production of the concerned product and other similar equipment can start completely in the domestic sphere based on the imported design. The same can be achieved via reverse engineering of the Foreign Product. Here, the recipient entity develops its engineering ability to modify the design provided by the OEM. This knowledge combined with the technical skills & know how, Production and Organizational knowledge acquired via different sources / regime like joint ventures, license etc.

v. *Step five - Capability to design needed product indigenously*

At this step it is assumed that the recipient of the ToT has attained the knowledge and capabilities to produce the major components of the concerned product, with minimal dependency on foreign design, technological know-how and know why, organizational knowledge required for production, technical skills & assembly line and other requisite infrastructure for the development, production & maintenance of the concerned product.

vi. *Step six - Production based of local R&D for new product*

This is the final step / stage for an entity to achieve in this strategy of independence in the production and development of the needed and desired product. This includes the capability of designing and manufacturing the concerned product completely in the domestic sphere using domestic components. This stage marks the self-sufficiency in the production and achieving the ultimate objective of the ToT.

Engineering strategy

Attaining absolute self-sufficiency is a tough task. Hence, for the development and production of most of the products, we need foreign components. These components are irreplaceable as the production of every requisite component domestically may not be effective and might compromise the quality of the product. As this process includes the development of skill and technical knowledge in multiple fields, this is where that the Engineering Strategy comes into picture.[117] The pre-requisite of this strategy is the creation of an adequate Industrial and Technological Base, after which the Path strategy can be replaced by this strategy. In simple terms, this strategy acts on the adaptation and development of an existing technology as per personal requirements, and has two types:

[117] M. Brzoska and T. Ohlson, *Arms production in the Third World*, (SIPRI, Taylor and Francis, 1986), Ch.: 14, 283.

i. *Add-on Engineering*

In this subtype of the concerned strategy Upgrading, Updating, Improvisation and Adaptation of an existing technology is done as per the specific use of the user by altering components, features and incorporation of indigenous components.[118] The example for the same will be Israel Aircraft Industries; IAI Kfir which is developed from French Dassault Mirage [5]. Likewise will be the Python (previously known Shafrir) missiles series; developed and produced by Iran's Rafael Advanced Defence Systems Ltd. is based on the Sidewinder Missiles.[119]

ii. *Add-up Engineering*

In this sub-strategy, there is a higher demand of technical know-how and experience of previous production. Here the underlying idea is to raise supply chain and integrate the imported component and technical knowledge to develop and produce a new product.[120] This strategy is by multiple nations and entities for production of their product, for e.g.: aircrafts and fighter jets produced by Embraer Corporations like the AMX Ground Attack Aircraft, Brazilian armored vehicles made by Engesa Corporation, South Korean Howitzers, etc.[121]

Both these strategies have their own importance. The first one, the Path strategy is a gradual step by step development of the indigenous industry towards self-reliance, it is a difficult goal to achieve, & in the present era of rapid changing technology, where non collaborative development of a technology is deemed an ineffective methodology, and result in a lag behind from other counterpart. The second one, the Engineering strategy needs a base of technical knowledge and production experience.

It is suggested that a developing entity should switch from Path to Engineering strategy after gaining the necessary prerequisite knowledge and infrastructure base for the development and production of the product. In the present market situation, it is encouraged to shift into this hybrid strategy model, where the production of desired technology can be done not only in an effective but also an efficient manner, and for the same, it is suggested that the shift to Engineering strategy be made either after step 3, step 4 or step 5, depending on the need of the situation.

Structure for the Transfer of Technology

The government has initiated the process of transforming the aerospace & defence (A&D) sector by taking policy decisions to develop an indigenous manufacturing base and consequently reducing the dependence on imports. The revisions in the DPP have clearly highlighted the

[118] *Ibid.*, Ch.: 10 "South Africa: evading the embargo", p.206.
[119] *Supra* at 4, 284.
[120] *Ibid.*
[121] *Ibid.*

gradual shift in focus towards indigenization. DPP 2013 clearly focuses on creating a conducive environment for achieving indigenization by stipulating preferred categorization for buy (Indian), buy and make (Indian), make categories and allowing the private industry to participate in maintenance transfer of technology (ToT) thereby providing a level playing field to it with foreign OEMs and DPSUs. This mandate will compel Indian companies and foreign OEMs to revisit their India strategies and will most surely stimulate increased strategic and technology partnerships between them.

The Government of India has also been successful in bringing much needed clarity in licensing process by releasing the defence product list and by clarifying that dual use products do no need licensing. However, the procedure for arriving at the value of indigenous content still seem sto be complex. This is what needs to be deliberated because there will be a number of practical challenges in compliance.

India's historical dependence on imports seems to be one of the important reasons for not focusing much on developing intellectual property. The manufacturing in India obviously has limitations because India's access to technology is limited and there are lot of bottlenecks in in-house capability development. The next aspect that needs to be dealt with is the structure of technology transfer, which is a crucial aspect of any agreement. The underlying goal while deciding upon a structure should not be limited not only to the development of the indigenous market, but also to obtain other spin off benefits such as job creation. The structures can broadly be categorized in a two-fold manner. The first structure is the horizontal structure, while the second one is the vertical structure.

Horizontal structure

Under this structure, the ToT contract is restricted to a single product. The exchange of rights over the access to the design, technical know-how, production, selling and other rights are available pertaining to just that product. It is very vital to understand the relevance of IPR in this structure.

Vertical structure

Under this structure, the OEMs share the rights of multiple products with the recipients. The extent of those rights of the recipient would vary with the products. The main aim for entering into a contract using this structure is for the acquisition of the requisite knowledge, skillset, and infrastructure needed for development and production of a particular range of product, rather than adopting a restricted approach as per the previous structure.

Nature and Types of ToT Arrangements

Defence procurement is governed by the Defence Procurement Procedure (DPP) which was first enumerated in 2006. The latest policy on DPP was unveiled recently in January 2018 with some amendment. It has been decided that the government will devise the DPP every year. A ToT Contract can be done through multiple channels. The following are four broad types of ToT Contracts (this categorization is subject to the division of labour and risk sharing among the parties of the contract):

1. Licensed Production Agreements,
2. Coproduction Agreements,
3. Joint Venture Agreements,
4. Foreign Design Assists.

Licensed Production Agreements

Under this agreement, the licensee, under a series of provisions, obtains the rights to deal with the OEM's products. These agreements are entered into bilaterally by the parties. Under this agreement, the parties own the rights and obligations to each other with primacy being given to the right of access to the products of the licensor by the licensee in lieu of a consideration.

Co-production Agreements

These are entity to entity agreements that permit the recipient to acquire technical know-how needed for the development and production of the concerned product. This may include the right for the production of all or some selected components of the product. These arrangements exclude the licensed production based upon the direct commercial arrangements by the OEM. There are two types of arrangements under this scheme; bilateral and multilateral agreements, and the same can also be arranged either horizontally or vertically. Horizontal coproduction, as can be inferred from the name, only deals with the production of the components of the concerned product or the concerned product as a whole only. This may also be completely or partially indigenous. Vertical coproduction means that the production complex of the recipient entity will not be limited for the production of the concerned product or its components only (subject of ToT) but will also be producing components for other products of the OEM. The product can be totally or partially indigenous. This should be the preferred arrangement as it is more profitable in nature.

Joint Venture Agreements

These agreements involve the development and manufacture of any product by multiple entities and significant level of inter-firm cooperation in Research, Design, Production, and Marketing and also a contribution from all signatories for creation of capital for the concerned project. These agreements are of two types; Equity and Contractual Joint Ventures.

Foreign Design Assistance

This arrangement is basically the assistance by the OEM regarding the design and development details of the concerned product, which is a necessary prerequisite for the development and manufacturer for any product. This will also include the blueprints of the target product. The foreign entity's scope of work will be limited only to the provision of the blueprint of the concerned product of ToT to the recipient. The components may be completely or partially indigenous but assembly is going to be completely indigenous.

Legal Instruments Necessary for TOT

After the identification of the type of Transfer of technology agreement being entered into, certain pre-agreements should be negotiated by the parties, along with critical provisions in the ToT Contract. The process of entering into a Transfer of Technology agreement is preceded by signing various agreements for sharing confidential information and trade secrets. Some of the agreements entered are:

- Confidentiality and Non-Disclosure Agreement (CNDA) – is entered so as to enable 'due-diligence' preceding the transfer of technology. Before finalizing a ToT Contract with the OEM, the potential recipient generally carries out a 'due diligence' test to check the veracity of the former's claims. For the purpose of safeguarding the IPR of the OEM, it is necessary to enter into a CNDA with the potential recipient as a prerequisite to carrying out the 'due-diligence' test.

- Material Transfer Agreement (MTA) – This is the second agreement that is signed after the CNDA. At times, for carrying out the 'due diligence' test, the entity would mandate procurement of the sample from the OEM. In order to protect the IPR of the OEM, it is necessary that the parties should enter into a MTA.

- Licensing Agreement for Transfer of Technology (LATOT) – This is the last agreement signed between the OEM and the recipient. This agreement provides details regarding the licensing areas, validity period and arbitration clauses.

Key Negotiating Points for the TOT Contract

For smooth implementation of the ToT Contract, the focus of the negotiating team of the parties should be on the following aspects.

Requisite Documentation

1. The necessary documents supplied must be in English so that ambiguity hurdles faced while translation are avoided.
2. The documents provided to the drafters and the ones used by the OEM or its vendors, for the purposes of manufacturing and assembling of the product in their factory, should be the same.
3. The documents provided must also be extensive to enable the recipient to manufacture, assemble, maintain, test and refit it when necessary.
4. The relevant approvals by certification agencies must also be provided to the drafters.

Upgrades for the Products

a. The OEM must undertake to provide all the documents that pertain to modifications, improvements and upgrades made by it during the lifetime of the product.
b. All of the above must be provided to the recipient at no additional costs.
c. Another requirement should be an exhaustive list of all the updates that needs to be provided to the recipient party on a yearly basis.

Extensive Training

The OEM must undertake to provide extensive classroom and on-the-job training to the nominees of the recipient party. The training should be done in such a manner so as to cover all the technical aspects of manufacturing, designing, software, system integration and the installation of the product. Training must also be given for testing and maintenance of the components of the product.

Technical Assistance

The OEM must also provide technical assistance to the recipient as and when required by the latter. The terms and timing of the technical assistance must be included in the contract itself. The OEM must undertake to provide honest and detailed answers to the queries by the recipient party at no additional costs.

Furnishing of special maintenance tools and test equipment

The OEM must provide exhaustive data on the Special Maintenance Tools and the Special test Equipment used by it during the manufacture, assembly and testing the product. All the data required for the manufacture of such SMTs and STEs must be made available to the recipient. If embedded software is being used along with the equipment, such details should also be provided to the recipient.

Product Support

The specified period, the OEM must provide a total product support to the recipient, including the provision of spare parts as well as the management of obsolete parts. If the OEM plans to discontinue the production of proprietary, it needs to prove a complete documentation regarding the technical aspects of the item in order to enable the recipient to develop an alternate source of supply. A detailed list of commodities that are needed for the manufacture and maintenance of the product along with details such as the involved costs, details regarding the sources and the data relating to the expected lifespan of the product must be provided to the recipient. It must be mandatory for the OEM to provide details regarding the technology, processes and the coatings involved while dealing with the specific components of the product. In case of a partial transfer of technology [M-ToT], the OEM must facilitate the procurement of technical support from its vendors or sub-contractors.

Delivery Schedule

The transfer of all the requisite documents, training period, provision of technical assistance, the supply of spares and proprietary items, SMEs and SMTs must be delivered in a phased manner. There should be a fixed delivery schedule for the above. In case of non-adherence of the delivery schedule, pre-designated damages must be paid to the recipient.

Independent Development

Leeway must be given to the recipient in the agreement to seek out local vendors and sub-contractors independently for the supply of requisite parts for the product. No clause in the agreement should compel the recipient to acquire the required parts from the OEM exclusively.

Warranty

The OEM must provide both documentation and material warranty. The documentation that has been provided to the recipient should be the same that was used by the OEM for its own production. The items that have been supplied to the recipient must be devoid of any material defects and should be quality guaranteed by the OEM. Performance guarantees to that specific design must also be guaranteed by the OEM.

Requisites of Robust TOT Contracts

It needs to be seen that, for an effective implementation and success of a transfer of technology agreement, there are four identification requisites that are common in all successful ToT Contracts;

Prudent Identification of Technology

The technology identified for transfer must enable the filling of critical gaps in commonplace knowledge and promote independency in the recipient party. The selection of an appropriate technology must be driven by need, not availability. The technology selected should be state of the art and should be multi-dimensional.

The OEM must be Reliable

For the success of a ToT Contract, the selected OEM must prove to be reliable. Before selecting an OEM, it capability to transfer must be examined along with its prior track record while dealing with similar engagements. Only those OEMs which have an honest and diligent track record must be selected while rejecting those OEMs which have a dubious ecord. No obligations must be imposed by the OEM making the transfer. The usage by the recipient must be unrestricted.

The Recipient must be Objectively Selected

After the development of the technology, the OEM must take care to identify such an entity which is the most suitable for the receipt of the technology for the development of the product equipment. A course of action that is the most effective and cost the least should be chosen by the OEM.

Close Oversight of Technology Absorption

At times, if the ToT is not fully absorbed and mastered by the recipient, the transfer of technology tends to be wasteful. The ToT must accelerate independent production by the recipient party. In order to improve the efficiency of the transfer, an independent agency must monitor its process.

Defence Offset Agreements

Inclusion of Offset Agreements (either direct or indirect as case may be) should be done, preference being given for Indirect Offsets.

Even though ToT Contracts intend to pass the expertise to the recipient to manufacture products from given components and inputs to the recipient, the objective has not been achieved. It has also led to certain disturbing patterns which have been detrimental to the Indian economy.

- The “Buy and Make” policy has failed to increase the technological proficiency of the Indian companies.
- ToTs have induced a culture of complacency among the PSUs. This is because of the fact that the PSUs have been reduced to just assembling from the components supplied by the OEMs.

- OEMs tend to be in a better position while negotiating a ToT Contract due to their complete knowledge of the product. At times, certain inputs and documents are deliberately excluded from the agreement by the OEM. Later on, the OEM tends to coerce the recipient into doling out additional sums of money for the excluded items.

Recommendations to Remedy the Status Quo

In order to reduce the fallacies of ToT Contracts, and enable the achievement of their objectives, the following suggestions may be considered:

- To increase the scope of innovation, there should be a limitation on Proprietary Items.
- The drafters should be well versed with the practices, complexities and the dynamics of a proper ToT Contract.
- Nomination of the officials for negotiation should be done with due diligence as it is a rigorous and complex activity.
- An Embedded List of Patents with the ToT product should be provided by OEM to ensure the freedom to operate, and the valuation for the same be done mutually by all the contracting parties subject to the market value, industrial returns & technological standing (latest, obsolete, etc.). This decision by the recipient should be made on the basis of Capabilities and Capacities.
- The ToTs should not prevent reverse engineering.

Issues and Challenges of Technology Transfer

Any business enterprise faces a no. of technology related issues. The more important of them are ways of technology acquisition, choice of technology, terms of technology transfer and creating local capability.

<u>Technology acquisition</u>

One of the major issues in technology relates to the mode of technology acquisition. Developing new technology may conjure up visions of scientists and product developers working in R& D laboratories. In reality, new technology comes from many different sources including suppliers, manufacturers, users, other industries, universities, governments and MNC's. Every source needs to be explored for new technologies and ideas. Each firm has specific sources for most of the new technologies. Essentially the question of how to acquire new technology is a "make or buy decision". In other words, should the firm develop the technology itself or acquire it from an outside source? The decision should be taken very carefully at this stage. Broadly the acquisition routes of three stages I) Internal II) External III) Combined sources.

I. Internal technology acquisition through in-house creation - This is the result of technology development efforts that are initiated and controlled by the firm itself. Internal acquisition requires the existence of a technological capability in the company. Internal technology acquisition options have the advantage any innovation becomes the exclusive property of the firm

II. External technology acquisition- External acquisition is the process of acquiring technologies developed by others for use in the company. External technology acquisition generally has the advantage of reduced cost and time to implement and lower risks. However, the technology available from outside sources is generally developed for different applications. Therefore, external acquisition should contain an aspect of adaptation to the acquiring company's application

III. Combined sources – Many forms of technology acquisition of combination external and internal activities. Combined acquisition seeks to overcome the limitation of internal & external sources, taking advantages of both the parties at the same time.

Choice of Technology

The second major source related to technology transfer is its "choice ". It is argued that it is the industrialized countries that developed technology and know- how thus developed will be mainly useful to them. This means that the rich countries become monopolists in developing, using and managing technology. This also means that the technologies tend to be designed for the production of high quality sophisticated goods on a large a scale, using as much as possible capital and higher level professional skills in place of sheer labour and replacing natural resources by synthetics. Care is to be taken while carrying out TOT from developed countries to developing countries. If the technology content and level are not appropriate, then the TOT can do more harmful than good.

Such "appropriate technology" raises several questions for the international/national managers. i.e. to what extent or feasible alternative technologies are readily available ? If not available, can the cost of developing more appropriate technology be justified? And what mix of factors other than difference in the relative cost of material, labour and capital should influence the managerial decisions.

Terms of conditions of technology transfers

The issue related to terms & conditions of technology transfer questions of the suitability of the transferred technology are related to each other. Some of the restrictive conditions, for example make the technology less suitable than it would or otherwise be. This clearly applies to such restrictions on prohibitions on the adoption of the imported technology as a bases for local R&D development and clauses stipulating that the results of a local technological R&D based on the imported technology must be transferred to the owner or supplier of the technology such

restrictive clauses clearly reduce the suitability of technology the effort of all concern to remove such conditional provisions. Cost of the technology transfer is a very serious issue for developing countries. 90% of the modern technology transfers to developing countries is controlled by MNC's. Who are essentially interested in getting highest returns from their inventions? Even, the developing countries reacted in their own way to face the restrictive clauses imposed by international business on their exports of technologies.

Creating Local Capability

Creating local technological capability is essential to absorb imported technology. Technology is not a simply a matter of blue prints, which can be transferred without any local effort to any part of the world. Each time some technology is installed some local adoption is required, which demands local technological capability. The need for local adaptation arises from the fact that the environment in which any technology operates is unique in a situation when it is installed. Difficulties are often found in the availability of skilled labour, the dexterity, training, education and experience, availability and quality of materials and components and infrastructural facilities including energy, transportation, water and communication. The local technological capabilities are also needed in order to adopt technologies to local conditions to improve productivity in the operations and to permit the attainment of international competitiveness and growth of exports.

Globalization

The world economies are passing through structural changes. These changes are driven by globalization of business as well as by the revolution in information, communication and transportation technology. The WTO is contributing to globalization by removing trade barriers between countries and evolving mechanisms for smooth conduct of trade among nations. The WTO has also evolved mechanisms to manage technology in better ways.

Barriers for technology transfer

The final international technology issues3 related to barriers and the problem encountered in technology transfer is the following:-

- A limited general understanding of the technology concept and the lack of a consistent frame work for its study.
- Lack of systematic planning for technology transfer in developing countries receiving the technology.
- Lack of bilateral scientific/ technology advantages in the process of technology transfer (mutual benefits)
- Lack of relevant frame work for analysis and evaluation of technology.
- Failure to include ergonomic aspects in technology transfer.
- Lack of attention to environmental considerations and assessment of technological impact.

- Failure to recognize the local potential for adoption of technology.
- Failure to determine the possible applications of the transferred technology.
- Restricting the feasibility study of technology transfer to financial assessment.
- Misunderstanding of the concept of technology appropriateness, hither to confined to only small and non capital intensive technologies.
- Presence of ethical problems within the technology transfer process.
- Failure to evaluate to consider conflict causing factors pertaining to the transfer technology.
- Inability to address end of life disposal of elements of new technology.

HR issues

The HR issues include cultural, technical education, skill level, language, discipline, commitment, attitude towards work and aptitude, etc. Culture affects both functional as well as non-functional. It acts as a barrier to mergers and acquisitions.

Policy Issues in Transfer of Technology

In regard to transfer of technology there are certain legal and policy issues which have to be addressed before technology can be effectively transferred and utilised. These issues are encountered both at international level and at domestic level by municipal governments which help in making technology transfer meaningful.

Some of such issues are issues concerning intellectual property right protection, competition law issues, business models or technology transfer vehicles, issues relating to encouragement of technology transfer from developed to developing countries, host country technology related issues, etc.

Effective redressal of these issues could only make the technology transfer useful and beneficial to developer as well as the recipient of the technology.

At the domestic level, for redressal of these issues countries have used a variety of policy instruments to influence and strengthen the generation, transfer and diffusion of technology. [122] However, such regime is at very rudimentary stage at international level.

Some of these policies issues are discussed briefly as under:

[122] Omer, Assad (2001). "An overview of legislative changes", in S. J. Patel, P. Roffe and A. Yusuf (eds.), *International Technology Transfer: The Origins and Aftermath of the United Nations Negotiations on a Draft Code of Conduct* (London, The Hague and Boston: Kluwer Law International)

i. Treatment of Intellectual property of developer

Prime issue which arise in technology transfer is the issue concerning the proprietary right of the developer of the technology. Developer who has invented the new technology which is the subject of transfer must have certain protection regarding his intellectual property. This protection comes through legal regimes concerning Intellectual Property Rights.

- Developer's right on the technology subject to the transfer

Ownership right of developer of the technology is the prime focus of protection in technology transfer agreement. Generally the technology transfer agreement defines the ownership right on the technology and the relationship that exists between the licensor and the licensee.

IPR regime tends to protect the intellectual property of the transferor by providing him various rights like patents, copyright, trade secrets etc.; which are generally the rights which are licensed in technology transfer agreements. Patents protect the developer of new devices and processes form unauthorised use by others. Similarly, copy right and trade secrets protect rights in original work of authorship and proprietary technology respectively.

For smoother flow of technology both within and without the nation boundaries it is desirable that community of nations should have their respective IPR regimes. As IPR regimes have been the classical policy instruments to influence the generation, transfer and diffusion of technology and international rule-making has preponderantly focused on the protection of IPRs. International rule-making in this field has a long-standing tradition.[123]

Further it is required that domestic laws relating to IPR should not be in contradiction with internationally acceptable IPR regimes. This is could be achieved by harmonising national law with international jurisprudence. Such harmonisation is required to facilitate easier movement of technology across nation's boundary.

As pointed by UNCTAD working paper on Transfer of technology[124] :

It has mainly centred on avoiding or lessening the consequences arising from disparities among domestic intellectual property laws as to the formal and substantial requirements of protection through basic principles aimed at:

- avoiding discrimination towards foreigners as regards IPR protection; and
- attenuating the territorial character of IPRs which obliges enterprises willing to expand operations to foreign countries to seek protection in each of them on the basis of differing formal and substantive requirements and procedures.

[123] Supra note no.2

[124] Supra note no.01 at page 18

ii. Encouraging Technology transfer

Till recently, encouragement and facilitation of technology from industrially advanced countries to the under developed countries has risen as a policy issue at international level. Legal mandate for the purpose of encouraging technology transfer comes from TRIPS Agreement includes a number of specific provisions in this regard.

Most notable in this regard is Article 66.2 requires developed countries to provide incentives for to enterprises and institutions in their territories for the purpose of promoting and encouraging technology transfer to LDCs in order to enable them to create a sound and viable technological.

In this regard, the draft UNCTAD Code of Conduct on the Transfer of Technology addressed the issue from various perspectives: the legitimization of specific domestic policies to promote the transfer and diffusion of technology; rules governing the contractual conditions of transfer of technology transactions; special measures on differential treatment for developing countries; and measures that would strengthen international cooperation.

Further UNCTAD in collaboration with ICTSD (International Centre for Trade and Sustainable development) prepared a report and put forward number of policy issues for promoting transfer of technology.[125]

This report reviews comprehensively the basic theory and evidence regarding how intellectual property protection affects incentives for international technology transfer (ITT). Analysis is provided of market-mediated ITT through trade, foreign direct investment, licensing, and personnel movements, along with informal means through imitation, reverse engineering, and spillovers.

Similarly for promoting technology transfer, major theme of discussion in 2002 World Summit on Sustainable Development (WSSD) where technology transfer from industrialised to developing countries emerged as an important issue.

Drafting of international Transfer of Technology Agreements

Drafting of international transfer of technology agreements, like other international agreements, is a difficult exercise as it involves various issues which have its implication for long period of time. Therefore special emphasises has to be paid to drafting of such contracts. And care has to be paid to avoid any sort of word or clause ambiguity that lead to conflict or brings about loopholes in the mutual commitments.

[125] See report "UNCTAD-ICTSD Project on IPRs and Sustainable Development- Encouraging International Technology Transfer"; Issue Paper No. 7.UNCTAD-ICTSD 2004.

A contract produces number of legal effects. The negotiations that precede the parties' agreement may give rise to obligations and, by engaging in those negotiations, potential partners may lose part of their freedom of action and may have to comply with certain behavioural standards. This is true, in particular, when the contract relates to a complex and wide reaching operations[126]. International transfer of technology agreements is one of such contract.

In drafting a contract there are certain provisions which should be mandatorily incorporated and met into the structure of the contract. Such provision should be very clear and unambiguous as they constitute heart and soul of a contract.

Some of such vital contracts terms and provisions which are very important to international transfer of technology contracts are listed below. Further as a word of caution, there is no such thing as a single "model", "miracle" or "all purpose" clause appropriate for all occasions.[127] Each clause should be carefully tailored to the exigencies of a given situation, taking into account the likely types of disputes, the needs of the parties' relationship and the applicable laws. [128]

i. Background and Recital Clauses

Background and recital clauses are the opening clauses of a licensing agreement which provides for the identity of the parties and manifest the basic purpose or the intention with which parties entered into agreements.

The parties to a contracts use recitals to set out a series of statement that they regard useful before approaching the body of the contracts.[129]

The recitals generally includes statements introducing the parties, licensor's area of expertise and experience in relation to the subject matter of the agreement, licensee needs and purpose for acquiring the technology, intentions as they relate to the licensing and their intention to be bound by the terms of the agreement.

Sample Background and recital clause:

"This Exclusive Technology Licensing Agreement (herein after called as Agreement), effective as of__ _____, 2012 is entered into by and between LICENSOR, __**_____**_Nanotech

[126] Marcel Fontaine and Filip De Ly, *"Drafting of International Contracts- An Analysis of Contract Clauses"* Martinus Nijhoff Publications; Leiden: Boston 2009

[127] Stephen Bond, How to Draft an Arbitration Clause (Revisited), 1 ICC Int'l Ct. Arb. Bull. 14 (Dec. 1990). As mentioned in R. Doak Bishop King & Spalding, "A PRACTICAL GUIDE FOR DRAFTING INTERNATIONAL ARBITRATION CLAUSES": Texas

[128] R. Doak Bishop King & Spalding, "A PRACTICAL GUIDE FOR DRAFTING INTERNATIONAL ARBITRATION CLAUSES": Texas

[129] Supra note no. 14 at page 59

research institute having principal office in Turkey, and LICENSEE, _____Railway Wagon Industries.

WHEREFORE, LICENSOR is specialised nanotechnology research institute based in Turkey. It has developed innovative anticorrosion and fire retardant coatings and polymers based on a proprietary nanotechnology. Such technology is first of its kind; it's cost effective and guarantees cent percent protection from all kind and level of corrosion or fire.

AND WHEREFORE, LICENSOR wished to commercially exploit its technical achievement by licensing the technology to LICENSEE based in Russia....Such licensing is for a term and as per conditions prescribed in this contract.

AND WHEREFORE, with this purpose in LICENSOR has approached LICENSEE... LICENSEE is international player in railway wagon design and has great potential to commercially exploit the technology.

NOW, THEREFORE, LICENSOR and LICENSEE in consideration of the premises and the terms and the condition herein provided agree as follows:-

.....

.....

....."[130]

ii. Definition and Interpretation clause

The basic purpose of definition and interpretation clause is to bring parties to a mutually agreement upon meaning to certain contract terms, so as to avoid any future contradiction as to the meaning and interpretation of any contract term.

Accordingly definition of the important terms used in the agreement should necessarily be provided with clarity, brevity and precision. The terms to be defined in this clause essentially depend upon the nature and the type of the contract entered into. However, there are certain terms in international commercial contracts which has been standardised to a large extend and they apply uniformly to all business types. Such contracts terms are called as *boilerplate clauses*.

Boilerplate clauses are those clauses which are copied from one contract to another not only within the same company or law firm but also across the legal profession and across borders.[131]

[130] For more international commercial contract samples refer to:- Morton Moskin(Ed.) Commercial Contracts – Strategies for Drafting and Negotiations. ASPEN Publications 2005 ; and Dennis Campbell and Reinhard Proksch,: "International Business Transactions- Commentary Forms and Documents " Kluwer Law International 2005

iii. Choice of Language

Choice of language generally figures in those contracts where parties have different national language or language of commerce. In such case it's quintessential that the authoritative language/s should be decided before hand. It is possible to have drawn a contract in more than one language but it more often than not lead to confusion in interpretation.

So it is desirable to choice an authoritative contract language at the time of contract negotiations. In choosing the language of the contract consideration has to be paid to the 'choice of law clause', 'jurisdiction clause' etc.

iv. Representations and Warranties

Representations and warranties clause is a declaration from the party conveying the technology that is free from any liens, security interest or any other encumbrances. And the licensor under the provision of the contracts is the rightful owner of the licensed technology.

Typically, the licensor will represent and warrant that all technical information delivered by the licensor under the provision of the agreement is accurate and complete; that the licensor has the power and authority to execute, deliver, and perform its obligations under the agreement and that all licensed patents and patent applications under which rights have been granted has been secured.[132]

Further it is also possible to include an Indemnity Clause from the licensor to secure a situation of breach in regard to the Representations and Warranties or where it is found to have been falsely made.

Sample Representations and Warranties Clause

LICENSOR hereby warrants and represents to LICENSEE following:

a. LICENSOR has full legal right, power and authority to execute, deliver and perform its respective obligations under this agreement.

b. The execution, delivery and performance by LICENSOR of this agreement does not contravene or constitute a default under any provision of law applicable or of any agreement, judgement, order, injunction or other instruments.

c. All licenses, consents, authorization and approvals, if any, required for the execution, delivery and performance by the LICENSOR of this agreement have been obtained.

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[131] Supra note no.15 at pg.104
[132] See supra note no.8

d. LICENSOR is the exclusive owner of the licensed technology and such ownership is free from all kinds of encumbrances.

e. This Agreement constitutes a valid and binding agreement of LCENSOR, enforceable against LICENSOR, in accordance with its terms and applicable law. [133]

Representations and Warranties clause occupies a very important position in international transfer of technology contracts. Generally, it is advised that in case licensor refuses to give warranties, licensee should reconsider entering into contract with him.

v. Financial or Payment and Royalty Clauses

Generally technology is transferred by developer with the intention of commercially exploiting his innovation. The developer of the technology relinquishes the possession of it with the expectation of a potential income that may be generated through the license consideration.

Similarly, in cases where technology is licensed by a university or research institutes or by an individual wherefore along with the commercial exploitation, investment in R& D for further development of the technology is also motive, financial provisions are important. Under such situations purpose of the transfer is usually to shift the financial burden for further development of technology from licensor to licensee.

Therefore, because of these reasons proper drafting of financial clauses is quintessential for a meaning transfer of technology. Such provisions should be drafted taking into consideration all relevant facts and situations.

Some of the important financial terms included under international technology licensing agreements are discussed below:

a. License Issue Fee and Up- Front Payment Clauses

b. Equity Ownership and Other Secondary Payment Provision

c. Term Payment Clauses

d. Royalty Clauses

License issuance fee and up-front payments are the initial most consideration payment made after the conclusion of the technology transfer agreement. License issuance fee is the lump sum amount of money paid by the recipient (licensee) of the technology to the developer (Licensor).

[133] Morton Moskin(Ed.) Commercial Contracts – Strategies for Drafting and Negotiations. ASPEN Publications 2005 at page 20.11 (vol.2)

Such license issuance fee can be aggregate sum or can be separate license fees paid for the different technology- for instance, one license issue fees for commercialisation rights of hardware and another issuance fee for the related software. [134]

License fee and up-front payment is generally decided by licensor taking into consideration all cost and labour he has to incur for the development of the technology and his potential profit expectations. Further, commercial feasibility and potential demand for the technology in market is also taken into consideration.

License Issue Fee and Up- Front Payment are generally lump sum and onetime payment for the technology transferred. Other than it licensor can include such kinds of payment clauses which go for a long period of time. These are Equity Ownership provisions, Term Payments and Royalty Payment.

Equity Ownership as the mode of consideration is used generally in cases where technology subject of transfer has a great market value and commercial potential. In such kind of provision allows the developer to enjoy the proceeds of technology for a period of time.

In equity ownership, equity interest is created in favour of the licensor in the license or an entity to be created by the license. It is generally done by allotting specific shares in the name of the licensor.

Similarly in **Term Payment clause**, arrangement for payment of certain consideration periodically or on the happening of certain occurrence is determined. For example, licensor can incorporate a provision for annual payment of certain money or payment on certain occurrence like achievement of a milestone.

The final financial provision of the technology transfer agreement is the payment of **royalty provision**. This clause reflects the recognition that without the licensor's initial development work and the licensee's subsequent commercialisation efforts, no practical commercial application would have been possible.

In a technology transfer agreement any one or more of the above mentioned consideration or financial clauses can be used.

vi. Choice of Law or Governing Law clause

Choice of law is the most controversial and complex clause in transfer of technology agreements. International transfer of technology agreements generally involves parties from diverse legal system governing the contrast.

[134] See Michael J. Jackson "Technology Transfer Guide" Edition 2001 Aspen Law & Business

In such a situation it is imperative on the parties to decide upon the governing law in regard to the enforcement of the contracts along with the deciding upon the forum which has to be approached in a dispute arose.

The governing law is important as it establishes the rules of interpretation, validity and performance of the agreement, as well as the consequences and corresponding obligations upon the breach of the agreement.

In case where parties could not agree on the governing law, such provision could be deliberately left over for the court to adjudicate upon. There are certain theories of how to determine the governing law of a contract in case where it is not specifically provided in the contracts. [135] Court generally considers these theories in the following order of priority for the purpose of determining the governing law:-

a) Tacit or implied choice.

b) Centre of gravity.

c) Policy interest.

d) Rigid presumptions, such as nationality or the law of the place of contracting or performance, and

e) Law of the forum.

Tacit or implied choice- in case where no governing law is expressly chosen by the parties, court shall look in to the tacit expression of the parties as to governing law. Such tacit consent can be imputed by court from factors like language, reference to statues, choice of court or arbitration.

Centre of gravity- Under centre of gravity theory, proximate connection of the contract with the governing law is considered. And that nation's law is only applied with which the contract is most proximate. For determining proximity factors such as currency of payment, location of the parties, place where contract was entered into, place of performance etc is considered.

On the same lines Article 4 of EC Draft Convention on Contractual Obligations of 1972 states that:

"In case where no express or implied choice, the contract shall be governed by the law of the State with which it is most closely connected."

[135] See Dennis Campbell and Reinhard Proksch,: "International Business Transactions- Commentary Forms and Documents " Kluwer Law International 2005 Chapter 12 A-9

Policy Interests- under policy interests' analysis, court determines the governing law on the basis of the policy need of a state. The state which has more pressing policy need as to the contract results, the law of that state is applied.

vii. Provision regarding further development and commercial exploit of the licensed technology

Provision regarding further exploitation of technology generally figures in vertical transfer of technology where technology flows from laboratory or individual to an industry. Main motive behind such transfer is to commercially exploit technology together with further development and improvement of it. Accordingly sometime clause is included in the contact which obliges the licensee to have R & D for further improving the licensed technology, so that the commercial interest of the licensor could be adequately protected.

viii. Term and termination clause

Term and termination clause defines the length of time during which the contract will continue.

A license agreement will state that the term will begin, and the obligation of the parties will take effect on its effective date and will continue until the date on which licensee's obligations to pay royalties expires.[136]

Transfer of Technology under UNCTAD Norms

United Nations Conference on Trade and Development (UNCTAD) is a principal organ of the General Assembly and deals with trade, investment, and development issues.

UNCTAD operates to formulate policies relating to all aspects of development including trade, aid, transport, finance and technology. Their objectives include maximizing trade, investment and development opportunities in developing countries and aiding them in their efforts to assimilate into the global economy on an equitable basis. The conference ordinarily meets once in four years to discuss the same and draft opinions, reports and new objectives in accordance with changing global relations.

Transfer of technology under the UNCTAD includes any of the below outlined situations:[137]

1) The assignment, sale and licensing of all forms of industrial property, except for trademarks, service marks and trade names when they are not part of technology transfer transactions.

[136] Lennon , Michael J. "Technology transfer Guide" 2001 Edition at page 1-19
[137] UNCTAD/DTL/STICT/2013/8.

2) The provision of technical expertise in the form of feasibility studies, plans, diagrams, models, instructions, guides, formulae, basic or detailed engineering designs, specifications and equipment for training, services involving technical advisory and managerial personnel, and personnel training.

3) The provision of technological knowledge necessary for the installation, operation and functioning of plant and equipment, and new and innovative projects.

4) The provision of technological knowledge necessary to acquire, install and use machinery, equipment, intermediate goods and/or raw materials which have been acquired by purchase, lease or other means.

5) The provision of technological components of industrial and technical collaboration measures.

TRANSFER OF TECHNOLOGY AND LAW IN INDIA

In India there is no specific statue dealing with the technology transfer and its regulations. However, Reserve Bank of India has promulgated certain policies regulating foreign technology transfer. [138]

RBI policy on foreign technology transfer recognises two routes for technology transfer:-

i. Automatic route which does not require any prior approval.

RBI accords automatic approval to all industries for foreign technology collaboration agreements under which-

- The lump sum payments not exceeding US $ 2 million ;
- Royalty payable being limited to 5 per cent for domestic sales and 8 percent for export, subjected to a total payment of 8 per cent on sales over 10 year period.

Payment of royalty up to 2 per cent for export and 1 per cent for domestic sales is allowed under automatic route on use of trademark and brand name of the foreign collaborator without technology transfer. In case of technology transfer, payment of royalty subsumes the payment of royalty for use of trademark and brand name of the foreign collaborators. Payment of royalty up to 8 per cent for export and 5 percent on domestic sales by wholly owned subsidiaries (WOS) to offshore parent companies is allowed under the automatic route without any restriction on the duration of royalty payments

ii. Government Route which requires approval

[138] www.**rbi**.org.in/upload/ECM/docs/FT**RBI**.doc

All proposals for foreign technology agreements not meeting the parameters for automatic approval are considered on merit by the Project Approval Board (PAB).This is chaired by the secretary, department of Industrial Policy and promotion, Ministry of Commerce and Industry.

Applications in respect of such proposals should be submitted in form FC/IL (SIA) to the secretariat for Industrial Assistance, Department of Industrial Policy Promotion, Ministry of Industry, Udyog Bhawan, New Delhi. No Fees is payable. Approvals are normally available within 4 weeks of filing the application

Model technology transfer agreement

Given below is model Exclusive Technology Licensing Agreement for the licensing of innovative anticorrosion and fire retardant coatings and polymers proprietary nanotechnology.

Model Exclusive Technology Licensing Agreement

"This Exclusive Technology Licensing Agreement (herein after called as Agreement), effective as of__ _____, 2012 is entered into by and between LICENSOR, _____ Nanotech research institute having principal office in Turkey, and LICENSEE, _____Railway Wagon Industries, based in Russia.

WHEREFORE, LICENSOR is specialised nanotechnology research institute based in Turkey. It has developed innovative anticorrosion and fire retardant coatings and polymers based on a proprietary nanotechnology (herein after referred to as TECHNOLOGY). Such technology is first of its kind; it's cost effective and guarantees cent percent protection from all kind and level of corrosion or fire.

AND WHEREFORE, LICENSOR wished to commercially exploit its technical achievement by licensing the technology to LICENSEE based in Russia....Such licensing is for a term and as per conditions prescribed in this contract.

AND WHEREFORE, with this purpose in LICENSOR has approached LICENSEE... LICENSEE is international player in railway wagon design and has great potential to commercially exploit the technology.

NOW, THEREFORE, LICENSOR and LICENSEE in consideration of the premises and the terms and the condition herein provided agree as follows:-

.....

.....

.....,,[139]

1. DEFINITION AND INTERPRETATION

In this agreement the expressions following have the meaning indicated below:

LICENSOR's Patent Right on the TECHNOLOGY shall mean all know-how, technical data, or other information of any kind regarding the design, manufacturing, operation, use or sale of any Licensed Product or other device for use in the fields and for the application specified herein.

.....

.....

.....

[This section of the agreement contains the important terms of this transaction, which require precise definitions by the parties to avoid, for one reason or another, ambiguities]

2. GRANTS

Subject to the terms and condition of this AGREEMENT, LICENSOR herby grants to LICENSEE an exclusive right and license, under the LICESOR'S Patent Rights to make, use, and sell LICESNED product all over the world around.

3. CHOICE OF LAW

The parties agree that this Agreement shall be deemed to have been executed and shall be subject to, enforceable and construed pursuant to the laws of_____ (Country) in which the principal office of _____ (name one of the parties to the Agreement) is located.

4. LICENSEE ISSUE FEE AND ROYALTIES

Under the terms of the AGREEMENT, LICENSEE shall be obliged to make following payments:-

a. License Issue Fee- On the transfer of the TECHNOLOGY, LICENSEE shall be obliged to make one time lump sum payment of License Issue Fee which shall be US $ .....

Amount has to be transferred electronically to the account of the LICENSOR.

[139] For more international commercial contract samples refer to:- Morton Moskin(Ed.) Commercial Contracts – Strategies for Drafting and Negotiations. ASPEN Publications 2005 ; and Dennis Campbell and Reinhard Proksch,: "International Business Transactions- Commentary Forms and Documents " Kluwer Law International 2005

b. Equity Ownership- On the transfer of the TECHNOLOGY, an equity interest shall be created in the name of LICESOR. Such equity interest shall be of the value of US $.....

c. Royalty Payment- After the transfer of the TECHNOLOCY, LICESOR shall be paid annual royalty payment of US $.....

5. CHOICE OF LANGUAGE

Notwithstanding any translation of this Agreement, whether or not contemporaneous with the negotiation or execution of this Agreement, this (...language...) version of this Agreement shall exclusively control.

6. GOVERNING LAW

This AGREEMENT shall be governed by the law of the REPUBLIC OF TURKEY, except to the extent that TURKISH conflict of law would require the application of the law of another state or country.

7. REPRESENTATIONS AND WARRANTIES

LICENSOR represents warrants and covenants:

a) That it is possessed of all patent rights, title and interest in the TECHNOLOGY and TECHNOLOGY documentation and other related materials and that it has the right to licence to LICENSEE in accordance with this Agreement ;

b) That TECHNOLOGY is propriety to LICENSOR and does not infringe any copyrights, patents, trade secrets or other intellectual property rights of any third party

c) That each of the knowhow concerning the TECHNOLOGY will be delivered, handed over, tested and accepted according to the Specifications and in a manner designed to cause minimal disruption to LICENSEE's normal business functions;

d) That the TECHNOLOGY patent furnished to LICENSEE is free and clear of all liens, security interest, claims, charges and encumbrances

8. TERM AND TERMINATIONS

This AGREEMENT shall commence and be effective upon the execution hereof by the parties, and shall continue thereafter for an initial term of five years. Upon completion of the initial term of this agreement, LICENSEE may review this AGREEMENT and the rights grant hereunder for a second five year term upon six month's written notice given to LICENSOR, upon the approval and consent of LICENSOR.

Bankruptcy/ Insolvency/ Change of Ownership- if LICENSEE shall become bankrupt, or become insolvent, or files a petition for bankruptcy, and/ or if his business shall be placed in the hands of receiver, assignee or trustee or in event of a merger or consolidation to which LICENSEE is a party, whether by the voluntary act of LICENSEE or otherwise, this AGREEMENT shall immediately terminate without the notice of either party.

Option at Default: Either party, at its option, may give notice of the termination of this Agreement if the other party defaults in the performance of any material obligation under this AGREEMENT, and if the defaulting party has not remedied the default within 90 days, has the right to terminate the agreement.

In event of Termination, LICENSEE shall have no further rights under the agreement and LICENSOR shall not be entitled for royalty payment or other payment except for those as has been decided by the adjudicating body.

IN WITNESS WHEREFORE, this agreement is made in duplicate and each party has caused its name to be hereunto subscribed, by its duly authorised officer as the date indicated above.

LICESOR	LICENSEE
BY: _____	BY: _____
[NAME]	[NAME]
[TITLE]	[TITLE]

Conclusion

Thus transfer of technology agreements are an important method for the transfer of technology between various entities, which may include either private firms, private or governmental companies, research institutions and laboratories and even private individuals. Such transfer of technology serves various purposes. At one place it is seen as the commercial exploitation of intellectual labour put by the developer in developing the technology. On the other hand it is also needed for the purpose of bringing about parity in technological dissemination particularly in those nations where technology is considerable at low level.

However, to make the technology transfer a meaningful and beneficial for both the transferor and the transferee it is quintessential that certain issues as has been discussed above should be properly addressed. These issues relates to various legal and policy matters.

Further, in technology transfer agreements, particularly relating to commercial exploitation and government cooperation agreements, special emphasis must be paid to the drafting of such agreement. Such special attention is required so that all rights of both the parties are clearly mentioned and no dispute should arise subsequently.

MODULE-IV

Defence Technology and IPR Issues

This Module aims to give a holistic understanding of the nature of transfer of technology in defence in India and the importance Intellectual Property Law plays in this process. India is a heavy importer of defence technologies and the framework of IPR laws needs to be concretely defined so as to avoid India facing infringement charges. However, this protection must also apply to Indian produced technologies for the purpose of preventing susceptibility of home research, development and equipment to powerful States. There are further several issues of IPR related to defence and national security, i.e., management of IPR during defence research and development and technology development, protection of IPR of strategic nuclear and dual use technologies and applications, negotiating patents during acquisition of military equipment, etc. This Module shall seek to clarify these murky areas vis a vis the Indian context and shall delve into the jurisdictional issues and legal inconsistencies that require revision in accordance with globalizing contexts and commercial frameworks.

Introduction

The science and technology has always played a major role in development of the society and it is considered as a tool to achieve the growth, development and economic prosperity. In today's context the development of science and technology is not only limited to the economic development but is also important to the national security and increasing the strategic capabilities of the nation. In this context, most of the nations are investing their resources to develop advance and modern technology to ensure the safety and security of the nation as well as to enhance their economic development. It is also pertinent to protect these inventions and innovations, which have been advanced in the field of defence strategic technology development. This in turn will enhance the supremacy of the state in the field of science and technology and will also strengthen the strategic defence sector of the country. In order to maintain the supremacy and to protect the inventions achieved in the field of defence science and technology it is important to look into the aspects of protection through the mechanisms of Intellectual Property Rights (henceforth referred to as 'IPR'). The IPR regime protects the inventions so as to maintain supremacy by indigenously built technology and by investing high cost resources in the field of defence strategic development.

In India, the Defence Research & Development Organization (henceforth referred to as 'DRDO') is major agency which responsible for the research and development in the field of military equipments. It works in various areas of military technology, which includes, the dual-use nature of technology, in particular, in a number of domains including atomic energy, outer space and other defence research. Despite India's credentials in non-proliferation, it has not benefitted from the advances of dual-use technologies. The research and development in the defence and strategic sectors have created competitions amongst nation states across the globe. India has been moving ahead steadily in the technology advancement in these areas.

Technology plays an important role in the development process of every country. Technology sharing and transfer at the international level assumes importance from the viewpoint of

technology suppliers and those who need technology. The technological advancements have certain political and economic implications, which have been playing a dominant role in technology sharing among the nations. The recipient of strategic technologies has always been confronting with a greater challenge especially in the context of understanding the nuances of patent and copyright regimes. The manner and mechanisms through which the recipient country can tackle the issues relating to the defence manufacturing from legal dimensions remains a part of this discourse.

In the era of free trade regime the protection of IPRs has become central to the industrial growth and to acquire the knowledge capital. Key infrastructure and defence sectors heavily rely on the IPRs for the protection of key developments and inventions in technologies. For defence establishments, the protection of intellectual property or working around IP is not only the commerce, but also it is about the country's defence and security. Hence, it is pertinent to the countries to focus on the issues of IPRs while they are trying to be self-reliant as far as its defence needs are concerned. Further, the defence establishments will have to grapple with the IPR issues such as patenting, copyrights, trademarks and geographical indications. Now the time has come for India to take IPR issues seriously particularly in defence manufacturing sector because the growth of private players in the defence sector both from domestic and foreign companies. These private players create a challenging environment for the inventions in the defence sector.

As of now India has no tradition of commercialization of knowledge, in recent past few strategic and defence institutions and academia have started looking in to the aspects of filing patents in earnest. It is well known fact that the innovation comes only through patents. The Western nations in general and the United States in particular have achieved dominance in filing the patents and increased its economic growth. India has been steadily learning the significance of IPRs regimes. The DRDO has over the years enhanced the number of patents applications. The Council of Scientific Industrial Relations (henceforth referred to as 'CSIR') has also been activating itself in terms of filing patents. Undoubtedly, these institutions have long miles to go when compared with the institutions of the United States and other developed countries.

India's defence research and development organisations have, during the last three decades, developed a strong knowledge base in critical defence technologies leading to the indigenous development of Integrated Guided Missile Development Systems, Main Battle Tank, Light Combat Aircraft, Radars, Sonars, Torpedoes, and Life Support Systems for the soldiers. The knowledge base and capital have been evolving. It is anticipated that India's 'Make in India' campaign, which has started by the current political regime at the union government, will attract the foreign direct investment in the defence-manufacturing sector. The understanding and the use of IPRs regimes in defence manufacturing sector would remain complex unless a serious attempt is made to delineate the indigenous and imported components. The protection of IPR regime can be possible only when India identifies its' core area of competence and protects them through this regime.

Attempts are being aimed to meet the military hardware requirements and also to provide the spin-off benefits from the technologies for the societal development. The defence organisations in India have been attempting to network with the knowledge base available in the universities and research institutions through the formal mechanisms of research collaborations and study. There are research boards, societies and extra-mural funding support for research and development in the universities, which have paid some dividends in India's mission for achieving considerable level of self-reliance in critical defence technologies.

On the one hand, India has been witnessing a series of changes in its abilities in research and development and on the other hand, India still seems not equipped with the efficacy and significance of the IPRs regime. At present we are facing a peculiar situation wherein value additions are being made imported defence technology and the question of IPR protection in such cases hangs in doldrums. This issue will form a major part of the present research from defence imports and manufacturing point of view.

These developments will involve intricate IPRs management issues, for example, management of IPR during defence R&D and technology development especially when it would be done in collaboration with private or foreign players. Joint ventures will also raise a number of legal and policy issues. It is generally believed that the protection of IPRs of strategic nuclear and dual-use technologies and applications, negotiating patents and other IPR during acquisition of equipment, systems and technologies, and counterfeiting and piracy of legally owned intellectual property will remain a source of concern for India.

At present, there lacks a coherent legal framework for technology transfer at the global and national level. This gap in the national and international legal system needs to be bridged. It is essential that IP related issues of inventions of dual-use nature are understood from the economic and legal dimension especially for dual-use technologies, materials and systems. It would help in streamlining the process of IPR and other legal interpretations.

At present, India is striving to become self-reliant in the strategic and defence technologies framework. It is necessary for India to become self-reliant due to changing dynamics. India has been experienced though sanctions regime and the United States in particular had severed its ties with India after it had conducted nuclear test in 1974. The United States' had also pressurized other nations not to cooperate with India. The fall out of the United States technological sanctions proved to be a boon in disguise for India.

India has, over the years developed R&D and technological capabilities in the dual use strategic and defence technologies. The DRDO has championed ballistic missile technology, which is absolutely indigenous. The strategic nature of research and development in ballistic missile technology has obviously been seen as an area where the IPR issues could become significant. The approach to technology development in defence has also been changing wherein a number of defence systems are being outsourced from regular commercial systems. In view of these

developments and technological advancements, India should evolve an appropriate strategy in protecting its interest through IPRs regime.

The overall objectives of R&D projects have been mainly to create an understanding which would be in consonance with the prevailing situations in dealing with intellectual property. The proposed study would be a modest attempt in exploring ways and mechanism in which India can become more proactive in emphasizing the relevance, significance and importance of IPRs protection through patents and also the protection of documents through copyright and trade secrets. If there is a clarity then the scientists and defence establishments will be competent enough to engage in safeguarding the national interest through IPRs.

Further, with the entry of the private sector in a key infrastructural sector like defence and their contribution in indigenous development also not devoid of complicated IPR issues. The private sector entry at present in the defence manufacturing has been well articulated. More recently, the Ministry of Defence has come up with broad contours of India's strategic partnership policy to encourage the private sector's role in production of cutting – edge weapon systems in collaboration with global players through joint ventures. These collaboration programmes may raise certain pertinent challenges relating to IPR in defence manufacturing sector.

The strategic partnership policy under the "Make in India", programme which is supposedly the thrust of the current government's agenda would be the beginning of new regime in four major segments of fighter jets, helicopters, submarines and armoured vehicles (tanks and infantry combat vehicles) for private sector players.

Brief History of International IPR

Intellectual Property Law has played a significant role in the development and protection of the Indian Defence sector. It finds its origin on the international platform with the creation of the Paris Convention of 1883, which was the first international treaty to regulate Intellectual Property and dealt with aspects like patents, industrial designs, trademarks, etc. The Berne Convention was adopted in 1886 and focused on separate issues, i.e., neighbouring rights and copyright. The Administrative Secretariats of these Conventions merged decided to create a single term for the rights dealt with in these documents. Soon afterwards, the General Agreement on Trade and Tariffs (GATT) was adopted in 1947, which consisted of three main Parts: Part I consisted of Most Favoured Nation clause and Binding Commitments; Part II was the Pacta San Servanda clause, or the good faith clause; and Part III contained the ratification clauses and steps to treaty formation. The contents of the Convention were originally against developed nation interests, so concessions were introduced and the right to reserve was implemented. However, this led to unfair refusals to abide by provisions that were beneficial to developing countries and created a great deal of controversy.

By 1967, the World Intellectual Property Organization (WIPO) was created as an agency of the United Nations. WIPO is the global forum for intellectual property services, policy, information

and cooperation and currently have a membership of 189 States. They aim to lead the development of a balanced and effective international intellectual property system that enables innovation and creativity for the benefit of all in accordance with the mandate, governing bodies and procedures set out in the WIPO Convention.

Eventually, GATT was replaced by the Trade Related Intellectual Property (TRIPS), which was formed as a product of the World Trade Organization (WTO). The principal variation that was introduced was the abolition of the right to reserve. States were required to ratify TRIPS wholly and if they did not, could not be parties to the WTO and would not be able to obtain the benefits it provided for, which cautioned States into ratifying and complying with TRIPS provisions.

Understanding the Framework of the Indian Defence Sector

India's march towards the acquisition of competitive defence technology and thus gain assured capability against the military threats it confronts has essentially two routes. The first is indigenous development and the second, import. The first route was adopted in the 1950s when the Defence Research and Development Organisation (DRDO), Defence Public Sector Undertakings (DPSUs) and additional Ordnance Factories (OFs) were established.[140] Despite considerable thrust in that direction, albeit with an understandably limited budget, progress towards self-reliance in defence technology has not reached the milestones that were set. While overall indigenous development and production has significantly increased in technology levels and volumes over the decades, it has been offset by a faster evolution of defence technology in the world. Consequently, the defence forces continue, as in the past, to depend on imports of competitive defence technology systems.[141]

The second route to acquire competitive defence technology is their import. Executed under the rubric of 'Transfer of Technology', this comprises of arrangements wherein foreign supplier firms provide technology for enabling the buyer to manufacture defence systems. Since indigenous capability was limited, India has been using Transfer of Technology to shore up its defence production capabilities from as far back as the 1960s and 1970s.[142]

Indian IPR Laws and National Security

An audit of security related arrangements in the national laws on IPR4-5 showed that there were security related arrangements in the laws identifying with licenses, outlines, coordinated circuits, and plant assortments, wherein the Government may disallow or limit the distribution of data as for development or correspondence of such data on the off chance that it was viewed as

[140] Krishnan, Nabanita R., *Critical Defence Technologies and National Security – The DRDO Perspective*, 3 JOURNAL OF DEFENCE STUDIES p. 92 (2009).

[141] Kevin Desouza, *Transfer of Defence Technology: A Critical Analysis*, IDSA, (Apr. 12, 2016), http://www.idsa.in/idsacomments/transfer-of-defence-technology_ka-desouza_120416.

[142] *Ibid*.

important for resistance purposes or biased to the enthusiasm of 'security of India'. The expression 'security of India' incorporated any activity important for the security of India which (i) identified with fissionable materials or the materials from which they were inferred; or (ii) identified with the movement in arms, ammo, and executes of war and to such activity in different products and materials as was carried on specifically or in a roundabout way with the end goal of providing a military foundation; or (iii) was taken in time of war or other crisis in worldwide relations. On the off chance that the creation was pertinent for safeguard purposes or nuclear vitality, authorization to document a patent application outside India couldn't be given without earlier assent of the Central Government.[143] The Government may make any move including repudiation of any patent, which it considered fundamental in light of a legitimate concern for security of India by issuing a warning in the official paper to that impact. There are no particular arrangements identified with national security in the laws on copyright, trademark, and geological sign.[144]

Research and Development by the Military and IPR

The Defense Research and Development Organization (DRDO) is the major logical office in the nation to complete R&D identifying with military gear and advancements. It is working in different regions of military innovation which incorporate flying, deadly implements, battle vehicles, gadgets, instrumentation building frameworks, rockets, materials, maritime frameworks, propelled processing, reproduction and life sciences.[145] The administration of IPR is probably going to assume a noteworthy part in fortifying resistance R&D and innovation improvement, the key elements of which are examined beneath:

- Detection of Science and Technology for IP Protection

The general R&D process may include doing fundamental research, connected research, utilization of aftereffects of research, advancement and exchange of innovation. All R&D ventures go for making new licensed innovation or create existing types of protected innovation.[146] This creation might be justified regardless of a lot of cash or of basic key essentialness in the event of military and resistance R&D. In both sense, the point of guard R&D associations ought to be to accentuate advancement of R&D concentrated on production of huge licensed innovation. Further, patent archives contain most avant-garde and most recent

[143] Hoekman, B.M., Maskus, K.E. and Saggi, K., 2005. Transfer of technology to developing countries: Unilateral and multilateral policy options. *World Development*, *33*(10), pp.1587-1602.

[144] Gupta V K, Security related provisions in IPR laws, Desidoc Bulletin, 27 (4) (2007) 5-14

[145] Home – Defence Research and Development Organization, Ministry of Defence, GOI, Online version at http://www.drdo.org/

[146] Mowery, D.C. and Oxley, J.E., 1995. Inward technology transfer and competitiveness: the role of national innovation systems. *Cambridge journal of economics*, *19*(1), pp.67-93.

mechanical data, which might be utilized by researchers and specialists when starting another venture or recognizing R&D open doors for innovative advancement.

The exceptional utilization of patent data makes it conceivable to distinguish suitable thoughts for innovation advancement, keep away from superfluous use and spare time and resources.[147] The quantitative systems of scientometrics might be helpful in recognizing R&D openings or advances for improvement.[148] The consequences of research, so got, may require an early distinguishing proof of creations that may require the IP assurance, especially, through licenses. For the most part, researchers themselves are the best people for taking a choice that they have gotten aftereffects of research that are required to be ensured by licenses. On a fundamental level, two criteria should be fulfilled, viz. (i) results are altogether unique in relation to what is as of now known, and (ii) comes about give positive esteem augmentations far beyond the current information. On the other hand, help of outside specialists may likewise be looked for in recognizing and deciding advancements that should be secured.

- Process of Patenting and Significance of Disclosure

The related measurement of IP insurance coming about because of barrier R&D is the issue of exposure of creation in the patent archives. The patent law requires that the patent applications ought to completely uncover the creation while making claims. In not doing as such, the patent may not be allowed. The exposure of delicate specialized data in patent applications may be impeding to the national security interests.[149] The national patent workplaces have the privilege to arrange a creation to be kept mystery and not to distribute the patent applications on the off chance that it is recognized that the innovation identifies with guard and a mystery request might be passed in such a case. This is an imperative issue wherein a fitting equalization should be set up between privileges of innovators and national security outcomes of the developments.[150] Sensible rules might be required for basic leadership in the national patent workplaces to practice an appropriate judgment on insurance of IP and issuing of mystery requests.

- Confidentiality in Research and Development

If there should be an occurrence of protected innovation, the portrayal 'secret data' has nothing to do with the military security arrangement: CONFIDENTIAL. Both unclassified and grouped

[147] Gupta V K, Ph.D. thesis `Intellectual Property Rights (IPR) Information for R&D Scientists in CSIR', Department of Studies in Library and Information Science, University of Mysore, March 2006.

[148] Karki M M S, Bibliometric analysis of patents: Implications for R&D and industry, in Emerging Trends in Scientometrics, edited by Nagpaul P S, Garg K C, Gupta 1999, 111-125.

[149] Kaplan and Kaplan, Giving away advanced technology: Intellectual property in military and aerospace programmable logic devices, http://klabs.org/richcontent/MAPLDCon03/abstracts/kaplan_a.pdf

[150] Hagedoorn, J., 1996. Trends and patterns in strategic technology partnering since the early seventies. *Review of industrial Organization*, *11*(5), pp.601-616.

data might be uncovered and authorized as 'private data' in the protected innovation sense. Researchers, in addition, sharing new thoughts and S&T data through distributions, keep know-how and a lot of specialized data private. Such data may incorporate logical, building, or specialized documentation as arrangements, outline, plans, quality control procedures, or manuals. It is alluring to perceive the privacy of such R&D data and create aptitudes for its protection.[151] Scientists as workers owe the business a commitment to act in accordance with some basic honesty and keep classified data private. All creations made by them should be kept in trust for the business for a specific timeframe even after the retirement.[152] A different 'secrecy assention' might be utilized while unveiling classified data, which may characterize: length; parties; what constitutes secret data; to whom the data can be given; the reasons for which it can be utilized; and what happens on lapse or end (for reasons unknown) of the agreement.[153] The requirement for satisfactory insurance of financially delicate data is additionally fundamental for military acquisition organizations to hold the certainty of industry. For instance, India and the US marked a General Security of Military Information Agreement (GOSMIA) in August 2002.[154]

Dimensions of Intellectual Property in India's Defence Research and development

It must be emphasized here that the relevance and significance of IP regimes cannot be undermined in strategic and defence sectors. A country like India has to explore ways and mechanism to capitalize the benefit of such existing framework. It must be noted here that India is a party to World Trade Organization (WTO) and The Agreement on Trade-Related Aspects of Intellectual Property Rights 1995 (TRIPS).

It has been seen that India requires to focus on patents in defence sector. The issues relating to IPR protection are becoming complex especially with regard to the varying approaches India will be undertaking in strengthening its manufacturing sector in defence. India's rigorous approach to 'Make in India' will be a modest attempt in exploring the avenues of cooperation with the major powers on the one hand and adding value to the various additions in different categories of technologies on the other. The role of IPR in this regard becomes central to the success of 'Make in India' campaign. As discussed elsewhere in the study, it is pertinent to point out here that the options before India in handling ToT are mostly centering around 'buy and make' and 'make'.

Co-operation in Science and Technology Collaborative Projects and IPR

[151] Gupta V K, Protecting confidential R&D information, Tech Monitor Journal of Asian Pacific Centre for Transfer of Technology (APCTT), 17 (3) (1999) 37-42.

[152] Gupta V K, Employer vs employee inventions: IPR issues in R&D organizations, Journal of Intellectual Property Rights, 5 (5) (2000) 239-250.

[153] Burge Smani, R.A. and Wheelwright, S.C., 2004. Strategic management of technology and innovation. *READING*, *1*(1).

[154] Koithara Verghese, Indo-US defence cooperation, Economic and Political Weekly, 6 August 2005.

DRDO is progressively teaming up with R&D establishments in colleges, national research centers and private business endeavors in matters identifying with protection R&D and innovation advancement. For viable cooperation, prior privileges of the teaming up establishments ought to be plainly spelt out. The usage of such coordinated efforts and responsibility for might be guided by the accompanying key principles:[155]

- Collaboration in Research & Development Projects

In a community oriented course of action in a collaborative agreement, there is a significant inclusion of both the partners in making commitment to the specialized parts of the exertion. On a fundamental level, the licensed innovation is together claimed by the teaming up S&T foundations and the subsequent advantages are to be similarly shared. On the other hand, the advantages are partaken in proportionate to the contributions of the working together gatherings.

- Research and Confidentiality IPR Contracts

The essential reason for an agreement is to get the examination contributions as an immediate contribution to all around characterized projects and missions of the organization giving the agreement. Typically, both substantial and elusive protected innovation are to be entirely possessed by the supplier of the cash/reserves; yet the beneficiary of the cash may have duty - free permit for his non - business utilize.

- Reports of Research and Innovation

Appropriate rules and practices should be set up for a decent arrangement of keeping records of research from the phase of first origination of the thought to a record of the considerable number of exercises helped out through different phases of the R&D extend.

The Role of IPR in Acquisition of Strategic Technology

The Government of India has supported procurement of key innovation and hardware by safeguard through government or private frameworks in India or abroad. It opened up private division cooperation in guard creation in 2001. Various significant private segment businesses from India have looked for cooperation for make of an extensive variety of resistance things. In perspective of expanding part of private division in barrier R&D and business, an adaptable way

[155] Gupta V K, Negotiating IPR in international science and technology cooperation, Journal of Intellectual Property Rights, 5 (2) (2000) 61-71.

to deal with IPR might be required in characterizing rules for information sharing, assurance and advantages.[156]

Improvement of innovation and frameworks in light of indigenous research and outline are an imperative segment of the Government's safeguard obtaining strategy which likewise acquainted a technique with arrange them as 'MAKE', in its Defense Acquisition process.[157] This spanned a basic hole that existed up to this point, and gave essential structure to expanded interest of Indian industry in the resistance division. On the off chance that acquisitions are produced using Indian ventures, the offer from the Indian business needs to unmistakably specify that the IPR privileges of the items are possessed by the Indian business. In the event that undertakings are financed by Ministry of Defense (MoD),the IPR have a place with the MoD.[158]

Utilization of Foreign Technology which is Protected in Other Jurisdictions without Consent

In procuring remote military innovations or gear that are secured in the nation of starting point of the advancements or by corporate R&D units somewhere else, the Defense Acquisition methodology of the Government of India try to guarantee that no encroachments happen while utilizing such advances or hardware as a part of the nation. In any case, from the perspective of resistance R&D and innovation improvement, the indications of the innovation so obtained may further be inspected in order to stay away from any antagonistic ramifications.[159] Firstly, authorization may not be required if such innovation is not ensured in India. Furthermore, if the secured innovation is utilized as a part of new segments, gadgets or some other new advances, a permit might be required for such utilize. It is not fitting to utilize secured innovation without appropriate consents either for use inside the nation or for utilize and fares to third nations.

Acquirement of Technology from Foreign Countries and Infringement

The hardware for which innovation for generation is not accessible in India has essentially to be foreign made to meet the operational prerequisites of the administrations. In situations when the innovation or gear are obtained from abroad, the Defense Acquisition methodology of the Government of India set down particular duties, which a merchant needs to give on patent rights and other scholarly property.[160]These incorporate the accompanying patent rights:

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[156] Flowers, S., 2007. Organizational capabilities and technology acquisition: why firms know less than they buy. *Industrial and Corporate Change*, *16*(3), pp.317-346.

[157] Patents and other industrial property rights — Defence Procurement Procedure 2006 & Defence Procurement Manual 2006, GOI, Online version at http://mod.nic.in /dpm/welcome.html

[158] Ibid.

[159] Slowinski, G., Stanton, S.A., Tao, J.C., Miller, W. and McConnell, D.P., 2000. Acquiring external technology. *Research-Technology Management*,*43*(5), pp.29-35.

[160] Ibid.

(i) there are no encroachments of any patent rights as per the laws winning in the particular nations of the merchants.

(ii) the costs expressed in the agreement incorporate all sums payable for the utilization of licenses, copyrights, enlisted charges, exchange imprints and installments for whatever other modern property rights.

(iii) the merchant reimburses the purchaser against all cases from an outsider whenever by virtue of the encroachment of any or every one of the rights specified in the past passages, whether such claims emerge in regard of make or utilize.

Unique Equipment Manufacturer (OEM)[161] should reimburse and secure at its own particular cost, the generation organization in regard of cost/cases/lawful cases/liabilities emerging from outsider case with respect to the presence of any patent or scholarly and modern property right of any such gatherings in India or from different nations.

On a basic level these IPR arrangements, in Indian guard contracts, guarantee that the hardware or innovation secured by it are free from encroachments or outsider rights and no extra expenses are made to it because of any shrouded IPR. Interestingly, experience of different nations like UK, shows that in protection related exchanges, it is suitable to set up clear standards for the exposure, exchange, utilize and responsibility for. The huge lesson to be learnt from the UK experience is concerning usage of IPR related arrangements in defence contracts. The Ministry of Defense in UK has built up an expound IPR strategy for its agreements.

The approach is actualized by uncommonly constituted Intellectual Property Rights Group (IPRG) in the Ministry.[162] Key parts of IPRG are to give an arrangement structure to managing IPR all through Ministry of Defense, and to give particular IPR benefits in support of its business in defining and arranging standard IPR conditions for contracts and, as a rule, giving suitable answers for its IPR related issues. Its expert staff is graduate researchers or designers, prepared as IPR authorities.

Rising Non-Nuclear Commercial Appliance

With developing globalization and opening up of the Indian economy, the non-atomic uses of a portion of the "recommended" substances are developing.[163] For instance, recommended

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[161] Hofmann-Wellenhof, B., Lichtenegger, H. and Collins, J., 2012. *Global positioning system: theory and practice*. Springer Science & Business Media.

[162] UK, The Ministry of Defence guide to intellectual property, 2003, Online version at www.aof.mod.uk/aofcontent/tactical/toolkit/content/ topics/iprguide.htm

[163] Molas-Gallart, J., 1997. Which way to go? Defence technology and the diversity of 'dual-use' technology transfer. *Research Policy*, *26*(3), pp.367-385.

substances like titanium, zirconium, graphite, or radioactive isotopes are utilized as a part of atomic innovation but at the same time are of utility, in different branches of innovation and are sought after by mechanical areas. The utilizations for titanium in industry are becoming speedier than any time in recent memory in applications in power era, substantial chemicals, PC industry, car industry, human inserts and a wide assortment of buyer items. The zircon and zirconium have a few uses in hard-headed/metallurgical fields. Graphite is utilized as a part of printed circuit board assembling, metalworking, and oils and added substances. Advance, utilization of radioactive substances has turned out to be broadly pervasive in horticulture and land utilize administration, nourishment safeguarding, and radio-pharmaceuticals. Indeed, even uranium or thorium might be utilized for creation, research, and make of customer items, for example, earthenware production and dishes or fabricate of refractories. Little amounts of Plutonium, U-235, and U-233 (under 200 grams aggregate) might be required for purposes, for example, organic and synthetic testing, alignment of instruments, neutron hotspots for use in modern applications or power sources to create warmth or power for remote climate stations, and space satellites.[164] Several private part business people assume a critical part in R&D and business action of such atomic related substances. New developments brought out by them have business benefits and are required to be secured by licenses and applicable IP laws. For instance, titanium apatite, a titanium compound, which looks like white particles is one result from an organization's examination work. It responds to light and advances deterioration of smells, contaminants, microscopic organisms, infections, and so on. Another case is it responds at first glance covered with ink. At the point when implanted in plastic, the plastic itself gets to be responsive. Trusting that titanium apatite can be connected in various different fields, the organization is further chipping away at finding different approaches to use this substance. Such developments might be of double utilize and business significance and would should be secured by taking patents.[165] It is crucial that IP related issues of innovations of double utilize nature are determined, especially, for double utilize materials and frameworks all together that the on-going projects of the Department of Atomic Energy in India proceed without legitimate obstacles and imperiling rising business interests. The applicable conditions of the Atomic Energy and the Patents Acts may should be changed keeping in mind the end goal to consider the developing needs of business interests of the non-atomic sector.[166][167]

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[164] US Nuclear Regulatory commission, an online version of the document can be found at http://www.nrc.gov/materials/miau/industrial.html.

[165] Fujitsu Intellectual Property Report 2006, An online version of the document can be found at www.fujitsu.com/downloads/IR/library/intellectualproperty/ip-report2006.pdf

[166] Damodaran A D, Implications of the new patents regime, challenges summarized - Part 6, Engineered materials –nuclear materials and systems, Online version at: http://www.patentmatics.org/index.html

[167] Ehni, H.J., 2008. Dual use and the ethical responsibility of scientists.*Archivum immunologiae et therapiae experimentalis*, *56*(3), pp.147-152.

- The Requirement for IPR Protection for Dual Use Innovations and Improper Commercial Use of Strategic Technology

Double utilize strategies significantly allude to innovation or item exchanges from barrier to regular citizen applications where the military development can be popularized after "light" alterations.[168] At the point when military innovation "pulls" the market, it is the common circle that tries to alter its frameworks keeping in mind the end goal to profit by overflows created by military request. In the inverse case, it is directing of double utilize and usage of proactive strategies by industry and barrier organization that get to be important to make open doors for reconciliation or exchange. The IPR assume a noteworthy part as an impetus to dynamic and productive coordinated effort in the turn off encounters from military to regular citizen circle.

They can really go about as an exchanging "item" or "money" in understandings between military "unit" (whether specialty unit of a firm or a guard research facility) and non military personnel business firms. India has noteworthy R&D and mechanical abilities in the double utilize advancements and inventions.[169] notwithstanding atomic related double utilize creations, there may emerge a few innovations from protection innovative work itself that may incorporate both military and non military personnel applications. The way to deal with innovation improvement in safeguard is likewise changing wherein various guard frameworks are outsourced from the consistent business systems.[170] There is in this manner a need to make a fitting IPR approach for double utilize creations and advancements—to search for turn offs as well as to further fortify the base for double utilize advances and developments in the economy.

Indo-US Civil Nuclear Deal

IPR are getting to be noteworthy to India's developing military collaboration with different nations like Russia or the US. For instance, Russia demanded for a concurrence on IPR as relationship between the two nations developed from a merchant customer relationship in protection collaboration to one went for joint R&D and advertising of products.[171] The proposed Indo-US Agreement in common atomic technology may likewise be vital from the perspective of Indian way to deal with a few of IPR issues.[172] The assention means to make extra limit with regards to era of atomic power and resume its atomic exchange and business with the US and

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[168] Fuhrmann, M., 2008. Exporting mass destruction? The determinants of dual-use trade. *Journal of Peace Research*, *45*(5), pp.633-652.

[169] Balasubramanyam, V.N., 1973. International transfer of technology to India.

[170] *Ibid.*

[171] Russia, India set pact on IPR, Defence India, 4 May 2005,www.defenceindia.com

[172] Burns, R.N., 2007. America's strategic opportunity with India: the new US-India partnership. *Foreign Affairs*, pp.131-146.

universally destroying the innovation foreswearing administrations.[173] The global exchange any framework like atomic reactors, their extras and frill furthermore fuel gathering frameworks including fuel cycle creation/preparing advances are vigorously IP secured by the significant corporate bodies in cutting edge nations including US. These will surely draw in the thorough conditionalities in IP security and transactions for innovation exchange, similar to all other non military personnel areas. Generally, the national IP approach articulated in the Atomic Energy Act 1962, which prompt to the advancement of endogenous atomic limit, may must be rethought with regards to IP issues identifying with the import of atomic reactors, their extras and frill and related innovations like fuel gathering systems.

National Security and Administration of IPR in Strategic Technologies

The test to national security is to manage the scope of dangers not just established in the conventional state-situated universal framework additionally to those that have developed as a result of the more up to date social, political and worldwide realities.[174] Today, national security is entwined with inside and outside security dangers including fear based oppression. The pilfering of trademarked or copyrighted or licensed items offers high income at a moderately okay. The robbery is progressively connected to national security because of composed wrongdoing systems' interest in lucrative forging and robbery schemes.[175] The proceeding with development of IPR burglary and exchange fakes and pilfered materials debilitates imaginative and innovative economies around the world.[176] There is a need to develop essential political will to act against such a robbery and get serious about licensed innovation burglary as a major aspect of the reaction to the new arrangement of national security challenges.[177] A few Governments have taken activities to present more grounded implementation of IPR laws. EU Directive in 2004[178] concerns the measures and methodology important to guarantee authorization of IPR. In

[173] Mian, Z., Nayyar, A.H., Rajaraman, R. and Ramana, M.V., 2006. Fissile materials in South Asia and the implications of the US-India nuclear deal. *Science and Global Security*, *14*(2-3), pp.117-143.

[174] Gopal D, India's security concerns in the post-9/11 era, in Globalisation and Regional Security: India and Australia, edited by Rumey D and Gopal D (Shipra Publications, 115 A, Shakarpur, New Delhi), 2007.

[175] INTERPOL, The links between intellectual property crime and terrorist financing—Before the United States House Committee on International Relations, One hundred eighth congress, 16 July 2003, http://www.interpol.int/Public/ICPO/speeches/SG20030716.asp

[176] Carter, A.B., 2006. America's New Strategic Partner?. *Foreign Affairs*, pp.33-44.

[177] Power, P.F., 1979. The Indo-American Nuclear Controversy. *Asian Survey*,*19*(6), pp.574-596.

[178] Directive 2004/48/EC of the European Parliament and of the Council of 29 April 2004 on the enforcement of intellectual property rights, http://ec.europa.eu/ internal_market/ copyright/documents/documents_en.htm

US, the Government is taking at the largest amount to convey and impact Governments of different nations to quit forging and piracy.[179]

India has issued strict requirement rules, viz. Licensed innovation Rights (Imported Goods)Enforcement Rules, 2007[180], which characterize the part of traditions decisively in fighting IPR encroachments at the fringes. The Central Government may limit or forbid import and fare of products encroaching licensed innovation privileges of the right holders under the Copyright Act, 1957, the Trade Marks Act, 1999, the Patents Act, 1970, the Designs Act, 2000 and the Geographical Indications of Goods (Registration and Protection) Act, 1999. In any case, it might need to address a few related issues like police activity against privateers, and following up strikes by acquiring feelings for encroachment.[181]

IPR LEGISLATION AND DEFENCE

The following is a list of legislative provisions relating to intersection of defence and security, and Intellectual Property ('IP') in India.

Relevant Statutes

A. The Patents Act, 1970

The most important provisions in the Patents Act 1970 ("Patents Act") from a defence perspective are those which provide the Central Government ('CG') or any person authorized by the CG - the right to use inventions for the purposes of government. An invention is used for the purposes of government if it is made, used, exercised or vended for the purposes of the CG, state government or a government undertaking.

The CG or any person authorized by the CG may, at any time after an application for a patent has been filed or a patent has been granted, use the invention for the purposes of government. The CG is under an obligation to notify the concerned patentee as to the use of his/her invention for the purposes of government. This obligation does not apply when the invention is used in a national emergency, for non-commercial purposes or in a circumstance of extreme urgency. The right has been granted to the CG with certain restrictions to prevent misuse. If the CG makes use of the granted patent, it is obligated to pay adequate royalties to the concerned patentee.

[179] The White House, US Government fact sheet: stop counterfeiting in Manufactured Goods Act, 26 March 2006 http://www.whitehouse.gov/ news/releases/2006/03/20060316-6.html

[180] Central Board of Excise and Customs, GOI, Notification issued by Government on Intellectual Property Rights (Imported Goods) Enforcement Rules, 2007, http://www.cbec.gov.in/cae1-english.htm

[181] Hoekman, B.M., Maskus, K.E. and Saggi, K., 2005. Transfer of technology to developing countries: Unilateral and multilateral policy options. *World Development*, *33*(10), pp.1587-1602.

The CG may acquire an invention which is the subject of an application for a patent, or a patent and all the rights in respect of the same, by publishing a notification to that effect in the Official Gazette. The aforementioned right is curtailed to the extent that the CG is required to pay the concerned patentee or applicant such compensation as may be agreed between the CG and the patentee/applicant, or in the event of failure of the parties to agree to the same, such compensation as may be determined by the relevant High Court.

In addition to provisions on government acquisition of patents, there are a series of provisions protecting national interest by restricting disclosure of certain information. The Controller of Patents has the power to give directions to prohibit or restrict the publication or communication of information with respect to inventions belonging to a class notified by the CG as relevant for defence purposes or where the invention seems to him to be so relevant. Where the Controller exercises his power, he is required to give notice of the same to the CG, which shall take the final decision on whether the publication of the invention shall be prejudicial to the defence of India. CG can also issue directions for prohibiting or restricting publication of information with respect to specific inventions even if no direction to such effect has been made by the Controller.

The secrecy directions given above are reviewed every six months, either by the CG or upon request by the applicant. If the CG finds that the publication of the invention is no longer prejudicial to the defence of India, or in case of an application filed by a foreign applicant it is found that the invention is published outside India, it shall forthwith give notice to the Controller to revoke the direction previously given. The CG shall not disclose any information relating to any patentable invention or patent application under the Patents Act which it considers to be prejudicial to the security of India. 'Security of India' has been defined as any action necessary for the security of India whichrelates to (a) fissionable materials or their derivatives; (b) traffic in arms, ammunition and implements of war, and such traffic in goods carried on to supply a military establishment, and (c) actions taken in time of war or other emergency in international relations. Any action taken by the CG, including the revocation of patents, which it considers necessary for the security of India is taken by a notification in the Official Gazette.

B. <u>The Designs Act, 2000</u>

The Designs Act, 2000 ('Designs Act') defines a design as only the features of shape, configuration, pattern, ornament or composition of lines or colours applied to any article whether in two dimensional or three dimensional or in both forms, by any industrial process or means, whether manual, mechanical or chemical, separate or combined, which in the finished article appeal to and are judged solely by the eye; but does not include any mode or principle of construction or anything which is in substance a mere mechanical device or any trademarks, property mark or artistic work.

The Controller-General of Patents, Designs and Trademarks has similar powers as its powers under Patents Act to direct non-disclosure of any information regarding a registration or

application under the Designs Act which s/he considers prejudicial to the interest of the security of India. The Controller-has power to cancel such registration in the interest of security of India.

C. The Semiconductor Integrated Circuits Layout-Design Act, 2000

A 'semiconductor integrated circuit' ('SIC') is a product having transistors and other circuitry elements which are inseparably formed on a semiconductor material or an insulating material or inside the semiconductor material and designed to perform an electronic circuitry function. A 'layout-design' is a layout of transistors and other circuitry elements and includes lead wires connecting such elements and expressed in any manner in a semiconductor integrated circuit.

The Semiconductor Integrated Circuits LayoutDesign Act, 2000 ('IC Act') contains provisions similar to the Designs Act regarding the security of India, with respect to disclosures and cancellation of registrations in the interest of the security of India.

D. The Protection Of Plant Varieties And Farmer's' Rights Act, 2001

The Protection of Plant Varieties and Farmer's' Rights Act, 2001 ('Plant Varieties Act') defines a 'variety'. Akin to powers under the Patents act, Designs Act and the IC Act, the Registrar of Plant Varieties has powers to direct non-disclosure of information regarding the registration or application of a variety under the Plant Varieties Act which is considered prejudicial to the interests of the security of India. The Registrar of Plant Varieties also has powers to take any actions regarding cancellations of registrations of such varieties which the CG may specify by notification in the Gazette in the interests of the security of India.

There are no specific provisions related to national security in the laws on copyright, trademark or geographical indications.

The DPP, 2016 and Intellectual Property

For 'Make' projects, the DPP provides extensive Guiding Principles ('GPs') on the allocation of IP rights of the Government under Appendix H to Chapter III. Under these principles, for most circumstances, the contractor retains the ownership of the IP generated under the contract, with the Government only retaining a license as per the terms given herein. However, if during the development of a prototype, the Government identifies a technology or product as being sensitive and requiring restricted access, through the Integrated Project Management Team ("IPMT") or any other expert body, it shall retain the full ownership of the IP of such a technology or product.

The types of IP covered herein can be divided into two categories:

a. Inventions and patents;
b. Technology licensing

i. Technical Data
ii. Computer Software

The Government gains licenses over the a) subject inventions and associated data, and b) all other data generated under the 'Make' contract. The rights accorded to the Government here are termed 'Government Purpose Rights' ('GPRs'), which mature into 'Unlimited Rights' after ten years from the vesting of such GPRs' with the Government. 'Government Purpose' for the purpose of the GPs has been defined as an activity in which the Government of India is a party, including cooperative agreements with international or multinational defence organizations, or sales or transfers by the Government of India to foreign Government or international organizations. 'Government Purposes' here also includes competitive procurement, but expressly does not include the rights to use, modify, reproduce, release, perform, display, or disclose technical data for commercial purposes or to authorize others to do so.

The GPRs apply at the 'prime' and the 'subcontract' levels. It requires the prime Development Agencies ('DAs') to incorporate the Government's rights as outlined in the Guiding Principles in all their subsequent subcontracts and agreements, insofar as technology development under the 'Make' category is concerned. Every sub-contractor shall have the same obligations vis-à-vis the Government as the prime contractor under the main procurement contract.

The contractor is also required to put into place a timely and efficient disclosure system to report IP generated under a 'Make' contract to the Ministry of Defence ('MoD'). It is also required to submit periodic reports about the commercialization and manufacturing activities undertaken for subject inventions under 'Make' contracts.

A contractor can elect to retain titles in any inventions made in performance of work under a contract. A contractor's failure to disclose such IP to the MoD in a timely manner or a failure to invoke his/her default right of ownership shall result in the IP vesting ab initio in the Government by implication. In the latter case, the contractor shall only be entitled to a license on such terms and conditions as the Government may deem fit. As per the GPs, such a license shall 'usually' be revocable and non-exclusive, but shall be royalty free. It shall extend to the contractor's domestic affiliates and subsidiaries and include the right to sub-license, but shall not be transferrable without the Government's prior approval.

It must be noted here that as per the GPs, the ownership of any rights by the contractor does not include an absolute right to transfer any software, product or documentation. Such transfer, including any export of the same, shall still be governed by the Export Policy, Export Guidelines, and all applicable laws, rules, regulations, orders and instructions released by the Government, and shall require the prior and explicit approval of the MoD.

In cases of dissolution of the DA, where the DA is not a consortium, the ownership of any IP generated under a 'Make' contract shall vest with the Government. If the DA in question is a consortium, the ownership of such IP shall vest among the partners as per the Joint Partnership

Agreement between them; however, the rights of the Government as licensee shall not be 'adversely affected' in any manner.

A. Subject Inventions

The DPP defines 'subject inventions' and 'invention' as follows: "'Subject Invention' implies any invention of the contractor conceived or first actually reduced to practice in the performance of work under a Government Contract. 'Invention' implies any invention or discovery that is or may be patentable or otherwise protectable under the Patent Laws in force in India." The GPs state that for all 'subject inventions' under the 'Make' contracts, the Government shall hold GPRs. The GPs indicate that a GPR is a non-exclusive, non-transferrable, irrevocable, paid-up (royalty-free) license to practice the subject invention or have it practiced on its behalf, throughout the world.

B. Technical Data ('TD') and Computer Software ('CS')

As mentioned earlier, the GPs state that the Government would gain GPRs over the data associated with the subject inventions, and 'all other data generated under the 'Make' contract'. In this context, the DPP indicates that the GPRs imply the right to use such TD and CS within the Government without restriction and the right to authorize any other entity, presumably to use the same, for any Government purpose including re-procurement. The following rights have specifically been included in the GPRs:

a. The right to use, modify, reproduce, release, perform, display, or disclose TD within the Government without restriction;
b. The right to release or disclose TD outside the Government and to authorize persons to whom such release and disclosure has been made to use, modify, reproduce, release, perform, display or disclose that data for government purposes;
c. The right to prepare and deliver form, fit and function data and manuals or instructional and training materials for installation, operation or routine maintenance and repair;
d. The right to prepare computer software documentation required to be delivered under the 'Make' contract; and
e. The right to make corrections or changes to the computer software or computer software documentation furnished to the contractor by the government.

In addition to the above, Government rights in CS to be delivered under contract specifically also include:

a. Use of a computer program with government computer(s);
b. Transfer to another Government computer;
c. Making copies of CS for safekeeping, backup, or modification purposes;

d. Modification of CS;
e. Disclosure to service contractors;
f. The right to permit service contractors to use computer software to diagnose/correct deficiencies, or to modify to respond to urgent or tactical situations; and
g. The right to disclose to contractors or any other third-parties for proposes of emergency repair and overhaul.

Guiding Principles for Ownership on IPR Pertaining to Software Products

1. The provisions on protection and disposition of intellectual property rights for the computer program & computer software should balance the commercial interests of Developer as well as the Government in a fair manner.
2. The provisions should be crafted with an understanding that computer software or computer program, developed by the Developer, could be delivered either as an integral part of a hardware, or bundled with a hardware, or independently in a computer readable medium (CD). As such, the provisions should be unified for the deliverables, whether the deliverable is a software or hardware or both tied up together.
3. The ownership of Foreground Information including computer programs & computer software and Foreground Intellectual Property Rights must rest with the Government, in case the Project is wholly funded by the Government. For other cases, the ownership of Foreground Information including computer programs & computer software and Foreground Intellectual Property Rights may rest jointly with both the Parties, except in certain exceptional cases.
4. The Developer may be given non-exclusive license on case-to case basis depending upon sensitivity of the Project to commercially exploit such technologies including computer programs & computer software, created during the Project, for civilian markets in India. The Government shall exercise its ownership rights so as to ensure that it can develop and produce such technologies including computer programs & computer software, generated during the Project, to the fullest extent for the Government purposes including defence applications free of any charge as well as free from any legal or other encumbrance/ hurdles
5. The Government should be able to claim the sole ownership of any foreground information including computer programs & computer software as well as foreground intellectual property rights, created during the Project, in the interest of national security in exceptional cases. However, the Government should exercise this option only in case of sensitive technologies, as determined by the Government.
6. The ownership of any background information including computer programs & computer software as well as background intellectual property rights, created by either the Developer or Government, prior to the Contract, should rest with the respective owning Parties. However, the Developer as well as the Government, should be free to use and reproduce each other's such background information including computer programs &

computer software as well as background intellectual property rights for the purposes of the development and production work performed under the Project.

7. All documentation considered, as background information including computer programs & computer software as well as background intellectual property rights should be marked accordingly by the Developer. Similarly, all documentation considered, as foreground information as well as foreground intellectual property rights shall be marked accordingly by the Developer.
8. Developer may have non-exclusive license for the commercial development of jointly held foreground information including computer programs & computer software as well as foreground intellectual property rights, generated during the Project for other than Government applications on case-to-case basis depending upon the sensitivity of the Project with prior written approval from the Government. Any royalty accrued to the Developer for such commercial development should be shared with the Government in proportion to ownership ratio.
9. Developer must not license any foreground Information including computer programs & computer software as well as foreground intellectual property rights, generated during the Project, to any third party without written prior agreement with the Government.
10. Government should have all rights including an irrevocable and royalty-free license for the commercial development, series production, continuing engineering support, product improvement of any background information including computer programs & computer software and background intellectual property rights as well as any foreground information and foreground intellectual property rights of the Developer, for the purposes of Government applications either by itself or by its licensees.
11. Whenever Government informs Developer that the interest of national security requires Development Agency to refrain from commercially supplying product or process including computer programs & computer software based upon any foreground information and foreground intellectual property Rights, created during the Project, to any particular third parties, or stipulate conditions in such commercial sale, Development Agency should abide by Government requirements.
12. The Developer is required to have a timely and efficient disclosure system in place for reporting of generation of any information including computer programs & computer software as well as intellectual property rights during the Contract. Further, the Developer shall be required to submit periodic reports about commercialization and manufacturing activities undertaken for processes or products embodying the foreground information as well as foreground intellectual property rights, generated during the Project.
13. The Government rights over the foreground information including computer programs & computer software as well as foreground intellectual property rights should flow down from the Developer to its all the sub-licensees or subcontractors.

14. Developer should not publish any foreground information including computer programs & computer software as well as foreground intellectual property rights, generated during the Project, so as to ensure that any proprietary or confidential information of the Government is not released and that any intellectual property rights is not jeopardized.

C. March-In Rights

The Government also has 'March-In Rights' for all items it has GPRs over, as per the GPs. The GPs define 'March-In Rights' as including the right to either work the patent by itself or have it worked on its behalf by another entity on behalf, in case the contractor fails to work the patent on its own within a 'specified and reasonable' period of time. Under 'March-In Rights', the Government can either require the contractor to grant a license or can itself grant a license for the following reasons:

a. The contractor fails to work the patent towards a practical application within a reasonable period of time; or
b. Health and safety requirements require the Government to grant such a license to act in public interest; or
c. For 'National Security Reasons'; or
d. To meet 'public use' requirements not reasonably satisfied by the contractor; or
e. For the contractor's failure to substantially manufacture the products embodying the subject inventions in India; or
f. In case of a failure on part of the contractor to comply with any of the requirements laid down in the Guidelines.

Addressing the Lack of IPR Provisions under the DPP

The "Buy & Make" element of Transfer of Technology is the primary group of capital acquisitions relied upon under India's Defence Procurement Procedure (DPP) for encouraging domestic manufacturing of equipment that originated in and is acquired from foreign countries. Hence, one instinctively expects the DPP to contain a comprehensive set of contractual provisions outlining the Ministry of Defence's IPR in technologies being received by Indian Production Agencies (IPAs). However, it has remained a relatively unaddressed area.

Though the DPP has been somewhat revolutionary in its policies regarding technology transfer and acquisition, the IPR provisions are yet to reflect the comprehensiveness of the plan. The following legal aspects of the ToT arrangements require further clarifications: (i) whether fees other than licenses can be charged by a foreign vendor on the Indian recipient in the form of running royalty payments, goodwill charges, lump-sum capital charges, etc., in which case the restriction of "no license fees" provided for in the policy could be rendered void; (ii) whether foreign manufacturing by Indian recipients can be restricted by the transferor, which would impact commercial manufacturing and sales; (iii) whether the Ministry of Defence as an offset

contracting party has any IPRs in the technologies being transferred to Indian entities; and (iv) whether the Indian entity receiving ToT in the first instance can subsequently transfer the same to another Indian entity.

ToT provisions under the DPP seem to be primarily about licensed production, rather than stipulating the minimum government-purpose IPRs in contractually-mandated deliverables with respect to terms of design, form, fit and function data and other technical documentation. There are essentially no contractual provisions outlining management of IPR related issues. The provisions also seem to contradict each other, for example the source code sharing provisions are contradicted by the quantitative cap that has been instituted on weapons created under one manufacturing license.

The "Buy & Make" provisions under the DPP have remained unaltered for nearly a decade. There is an urgent need for recalibration and elucidations on various operative and legal issues within the Policy and some basic level renovation and restructuring. This reformative process could perhaps include other important contracting issues as well as provisions pointing specifically to national security issues.

The transfer of technology aspect of defence transactions and conduct have been inadequately addressed in India's DPP. Their lack of an effective IPR regime to elucidate upon the causes and consequences of certain deals reflects the inability of the Indian government to ascertain effective policies and produce regimes that not only provide clear and sufficient information regarding the exchange of technology between countries, but also create a veil of knowledge and forethought. What India needs to enhance in order to strengthen its defence structure is its transfer of technology specific provisions with a clear indication to IPR impacts and requirements for the involved parties.

Comparing with the USA and the UK, we observe that there is a need to allocate IPR to different bodies in order to avoid concentration of power in the hands of few. The USA's regime dictates that their equivalent to the Ministry of Defence is to receive the IPR rights for all defence deliverables to the United States. This creates a system of power apportionment, which ensures that intellectual property concerns are addressed and specifically detailed and laid out.

India would need to strengthen its Intellectual Property (IP) protection regime to give confidence to defence sector investors.The Global Intellectual Property Centre of the U.S. Chamber of Commerce has scored India a very low 6.95 on a scale of 30 for IP protection, while the U.K. has a score of 27.59. India scored the least among the 25 countries surveyed and highlights the amount of catching up India needs to do.

In the UK, the principles of the Ministry of Defence's approach to IP to form a top level statement of policy, which comprises of a number of Principles and Policies. They clearly set out the Ministry's approach to the acquisition of user rights in, or in some circumstances ownership of, intellectual property arising from contracts it funds, and how it will treat other IP owned by

its contractors and suppliers. The statement strikes a balance between the Ministry's need to deliver military capability and industry's commercial interests as a consequence of their private venture investment.

Transfer of Technology (ToT) & Relevance of IPR

Technology transfer is a process by which a firm/ country gains access to and employs technology developed in another firm/country through market or non-market transactions or spill over. ToT is never sold as a commodity. For most developing countries advanced technologies will have to be imported. Hence need to synchronize procurement and cost effective acquisition to be in tune with Technology and reconcile competing interests with, set targets for intellectual property rights (IPR).

The OEMs guard their IP, and inhibit/ hesitate the collaborating partners to bring in cutting-edge technology. Practically, OEMs do not possess all IPRs for platform related technologies as many of such vest with their Tier suppliers. Today OEMs are integrators with various assemblies/ subassemblies being manufactured by their Tier 1 & Tier 2 partners and as such the IPR of different parts are held with different partners. Thus expecting the overall IPR to be acquired from OEM may not be feasible, though he may facilitate. ToT should be made directly to Indian industry/selected production agency rather than to DRDO, who may then share the technology to identified industry participants with proper safeguards.

IPR and Transfer of Technology and Equipment

Acquisition from Indian Industry

The first type of transfer to address is that from Indian industry. The Government has encouraged acquisition of strategic technology and equipment through either government or private systems in India or abroad. Because of the private sector's increasing role, a flexible IPR regime to define rules for knowledge sharing, protection and benefits needed to be created.

Development of technology and systems based on local research and design form an important part of India's defence acquisition policy, leading to their categorization in the "MAKE" defence acquisition procedure. The Modi government has adopted new procedures to deal with defence acquisitions in private sectors. The new Defence Procurement Policy 2016 is a policy dedicated to creating the momentum for pushing India's private sector to participate more in military manufacturing. The new policy places the highest preference to a newly incorporated procurement class called "*Buy Indian-IDDM*", with "*IDDM denoting Indigenous Designed Developed and Manufactured*". It has categories of funding for R&D and describes what kinds of procurements and R&D are to receive either Government funding, Industry funding, or Ministry of Micro Small and Medium Enterprises funding.[182]

[182] Ashok Atluri, *DPP 2016: A Game Changer For Indian Defence Industry*, BUSINESSWORLD, (Jan. 21, 2016),

Now, in case of acquisitions made from Indian industries, the offer must clearly state that the IPR rights of products is owned by the industry itself, and if funded by other ministries or bodies, ownership of IPR must be directed to them.

Acquisition from Abroad

The second type of transfer involves acquisition from abroad. Equipment that is not available in India but is necessary for the production of certain technologies and to meet the operational requirement of resources is imported. The government has laid down concrete guidelines and commitments on patent rights and other IPR with respect to acquisition from abroad, which a vendor must abide by and guarantee. The rights include the following:

(a) No patent infringement in any of the countries the acquisition transaction is taking place between;

(b) Prices stated in the contract include all amounts payable for use of copyright, trademark, patent, and any other industrial IPR;

(c) The seller indemnifies the buyer against all claims of any infringement mentioned in the above two points;

(d) The seller is responsible for completion of supplies including spares, Special Testing Equipment, technical literature and training aggregates, irrespective of infringement of above rights or supplies.[183]

Acquisition without Country of Origin's Permission

The next kind of technology transfer comes in the form of usage without the country of origin's permission. Defence Acquisition Procedures tend to ensure that such usage leading to infringement does not usually take place. But, the manifestations of this defence R&D and technology development need to be observed in order to void any adverse implications, i.e., permission may not be required if the technology is protected in India, or if the protected technology is used in some new components or technologies, a license may be required for usage of the same. But, it is generally not advisable to use protected technologies without permission.

Infringement Policies with Reference to the UK

The Original Equipment Manufacturer is to indemnify and protect the production agency with respect to costs, claims and liabilities arising from third parties regarding the existence of any patent or IPR in India or from other countries. These IPR provisions in defence contracts are created to ensure no extra costs and liabilities arise out of infringement due to any hidden IPR.

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http://businessworld.in/article/DPP-2016-A-Game-Changer-For-Indian-Defence-Industry/21-01-2016-90506/.

[183] V.K. Gupta, *India: IPR and National Security*, 13 JOURNAL OF INTELLECTUAL PROPERTY RIGHTS, 322, 318-325 (2008).

Other countries like the UK operate slightly differently, however, wherein it is appropriate to establish principles and conditions of disclosure, transfer, use and ownership of IPR. Even the implementation of these IPR provisions in defence contracts differs from other countries like India. The Ministry of Defence in the UK has established an elaborate IPR policy for its contracts, which is implemented by a special body in the Ministry known as the Intellectual Property Rights Group (IPRG). The IPRG's principal functions include providing a framework for dealing with IPR throughout the Ministry of Defence and to provide specific IPR services in dealing with contracts, such as negotiating the terms and standard conditions of IPR in contracts, providing solutions to IPR related problems, etc.[184]

IPR issues in Nuclear Technology Transfer

The Indo-US Nuclear Deal

On October 1, 2008, the United States Congress gave final approval to an agreement facilitating nuclear cooperation between the United States and India. The deal introduced a new aspect to international nonproliferation efforts. The deal lifts a three-decade suspension on nuclear trade with India imposed by the United States, and allows for U.S. assistance to be provided to India's civilian nuclear energy program, and expands U.S.-India cooperation in energy and satellite technology.[185] But critics in the United States say the deal fundamentally reverses half a century of U.S. non-proliferation efforts, undermines attempts to prevent states like Iran and North Korea from acquiring nuclear weapons, and potentially contributes to a nuclear arms race in Asia.

Through this agreement, India agreed to allow inspectors from the International Atomic Energy Association (IAEA) of the UN access to its civilian nuclear program, and by March 2006, India promised to place fourteen of its twenty two power reactors under IAEA safeguards permanently.[186] However, the Ex-Prime Minister, Manmohan Singh, stated that New Delhi retained the sole right to determine such reactors as civilian, so there were no constraints against India to build future nuclear facilities, whether civilian or military, as per national requirements. Further, the deal stipulates that military facilities-and stockpiles of nuclear fuel that India had produced up to that point would be exempt from inspections or safeguards.

However, the deal resulted in India signing an Additional Protocol, which allowed for more intrusive IAEA inspections of its civilian facilities. Further, India agreed to continue its moratorium on nuclear weapons testing and to commit to strengthening the security of its nuclear arsenals. Consequently, India also began efforts to sign an agreement with the United States that

[184] *Ibid*.
[185] Jayshree Bajoria, *The US-India Nuclear Deal,* COUNCIL ON FOREIGN RELATIONS, (Last Updated: November 5, 2010), http://www.cfr.org/india/us-india-nuclear-deal/p9663.
[186] Greg Webb, India, *IAEA Reach Safeguards Agreement*, NTI, (Mar. 5, 2008), http://www.nti.org/gsn/article/india-iaea-reach-safeguards-agreement/.

would ban the use of fissile materials in weapons manufacture. India further agreed to prevent the spread of enrichment and reprocessing technologies to states that don't possess them and to support international nonproliferation efforts.

Through this nuclear deal, U.S. companies are now able to build nuclear reactors in India, provide nuclear fuel for its civilian energy program, and sell other forms of technology for similar purposes. India is now eligible to buy U.S. dual-use nuclear technology,[187] potentially creating the material for nuclear bombs. It would also receive imported fuel for its nuclear reactors.

The agreement purports to create supplementary capacity for the generation of power and resume its nuclear trade and commerce with the United States, thereby globally disassembling the existent technology denial regimes. The trades covered under this umbrella agreement, i.e., trade in nuclear reactors, their spares, fuel assembly systems, etc., are subject to heavy IP protection by corporate bodies existing in advanced countries like the United States. Thus, India officially became likely to usher in billions of dollars worth of civilian nuclear technology.

Because of the rigorous conditions in IP protection being applicable to transfer of technology affiliated with all civilian sectors from this agreement, a re-examination of certain domestic legislations in the context of IP issues involved in transfer of technology, like the Atomic Energy Act 1962, were required.

Transcending Agreements, Breaching Generality and Evaluating the Current IPR Framework

India's nuclear power expansion programme greatly relies on imported technologies, which have been developed at high cost and risk over a long period, which leads the to expectation of compensation. When the technology is transferred, the provider will want to ensure that its competitive advantage, as the developer of the technology is protected. There is a lot of importance being placed on the localization of transfers also.

Intellectual property has an international dimension, and technology providers want to ensure that the host country honours, recognizes and enforces their IP rights. The principle behind patent protection is that in return for disclosing his invention, the inventor or owner is given limited exclusivity for it and thus provided an exclusive right to make, use and sell the invention within the jurisdiction of that patent.[188] Nuclear activities have shaped an attenuating world demanding wide-ranging international co-operation. The TRIPS Agreement gives freedom to each country to structure its own IP related laws and confirms that the patent laws are

[187] Including materials and equipment that could be used to enrich uranium or reprocess plutonium.

[188] Vaibhav Saxena, *Nuclear Technology Transfer – Intellectual Property Issues*, NUCLEAR LAW ASSOCIATION, (Feb. 13, 2014),
http://www.nlain.org/blog/nucleartechnologytransfer-intellectualpropertyissues.

'territorial'. Patent laws are therefore, national in scope and eventually IP rights may need to be enforced through the national courts.

According to Section 20(1) of the Atomic Energy Act, 1962, no patents shall be granted for inventions which in the opinion of the Central Government are useful for or relate to the production, control, use or disposal of atomic energy or the prospecting, mining, extraction, production, physical and chemical treatment, fabrication, enrichment, canning or use of any prescribed substance or radioactive substance or the ensuring of safety in atomic energy operations.[189] As a corollary to this, Section 4 of the Patents Act, 1970 provides that "No patent shall be granted in respect of an invention relating to atomic energy falling within Section 20(1) of the Atomic Energy Act, 1962".[190]

Consequentially, inventions relating to those provided under Section 20(1) cannot be patented in India and in the absence of patent protection their inventors have to protect their rights through a confidentiality clause or a separate confidentiality agreement so that in case of breach, the supplier can be compensated. But, this remedy is only enforceable against the buyer, and not the government or regulatory body this buyer has communicated the sensitive IP protected information to in compliance with local regulatory requirements. Therefore, they cannot be held liable for breach of confidentiality. Obviously IPR rights are *rights in rem*, while contracts normally bind the parties concerned. Yet it can be argued that the buyer may still be liable if it failed to inform the government or the regulatory authority of the proprietary nature of third party IP related information submitted to them in compliance with the applicable local laws.[191]

Though confidentiality agreements play a noteworthy role in protecting IP, they can only at best secure compensation for breach of contract between two parties, but cannot act as a substitute for clearly demarcated laws that are enforceable through deterrent penal provisions. Therefore, true international cooperation for protection of IP is necessary and can only flourish in an atmosphere of mutual trust and equality by digging at the currently prevalent fragmented 'territorial' approach reflected in the WTO-TRIPS international IPR regime and the out-fashioned national laws like Section 20(1) of the Atomic Energy Act and Section 4 of the Patents Act, 1970.[192] This greatly relevant in the context of highly specialized technological endeavours such as the nuclear sector and merits treatment of a premonition that the host government might find it challenging to interest project participants and to realize the desired levels of localization and transfer of technology to the extent to which the host country shows lack of respect for IP rights. Therefore, we are gravely in need of new approaches for IP protection.

[189] Sec.20, Atomic Energy Act, 1962.
[190] Sec.4, The Patents Act, 1970
[191] *Supra*, note 10.
[192] *Ibid*.

INDIA'S INDIGENOUS DEVELOPMENT IN DEFENCE AND IPR CHALLENGES

India had been a victim of technological sanctions until recently. The United States in particular had imposed technological sanctions against India after Pokharan I. The technological sanctions on strategic sectors had slowed down the developments in defence technologies manufacturing sectors. However, India showed its resilience and moved steadily towards indigenization. India has paid the price in terms of time and money. The technological sanctions against India proved to be a boon in disguise. India, in turn, became self-reliant. The developments in the defence technologies sector have witnessed a number of challenges including the intensification of the Public-Private partnership.

In the current context, India has been able to make a moderate base in defence sector. The advances made in the defence technologies over the years have shown lot of successes in the land, air and sea based systems. The current focus in India has been on indigenization of defence production. The changes made in the 2017 defence procurement policy and recently notified changes to the FDI policy have demonstrated India's 'will' to focus on indigenization. India certainly has been weak in total weapon systems. Hence, the policy changes are very much welcoming because it will pave the way for foreign technology in armament and weapon systems which would become more accessible in the domestic market.

The intellectual property rights issues related to defence in the overall context of India's strategic sectors obviously poses challenge mainly on management of IPR during defence research and development and also on the overall protection of IPR of dual use technologies and their applications. How does India negotiate on patents and other IPR related issues during the acquisition of military equipment and technologies remain a major part of ongoing discourse. There is no denying the fact that the IPR remains significant in defence acquisition procedures. If there are no adequate mechanism to protect IPR, there might be serious risks to national security from piracy of trademarked or copyrighted or patented products.

India would require to understand these complexities and build a strong mechanism so that it can act against piracy and also protect the IPR from the probable theft. As mentioned elsewhere in the report that the IPR is basically evolved to generate and protect new ideas, inventions and the overall developments in science and technology contributing to both national strategy and social objectives. Undoubtedly, the science and technology play a dominant role in managing national security. India has experienced and witnessed a number of advances in defence research and technology development including the nuclear and space capabilities, complete range of defence technologies such as armaments, aeronautics, electronics, information systems, sensor systems and marine systems.

Adequacy of IPR Protection Laws

During the defence research and development, the intellectual property is created and hence protection of IPR becomes a greater responsibility. In the cases where, India has been planning

to acquire and procure technologies from abroad, the ownership of intellectual property has to be found out during the negotiating stage. It is obvious that the security orientation of S&T is very much related to IPR. It determines the technological superiority and ultimately defines military prowess of a country.

One has to understand the security related provisions in IPR laws. It will obviously be a complex task because of the classified nature of various contents. There are security related provisions in the laws relating to patents, designs, integrated circuits and many other platforms where the Government might prohibit or restrict the publication of information with respect to invention or communication of such information if it was felt important for defence and national security purposes. In a number of cases, if the invention was relating to the defence and national security, permission to file a patent application outside India could not be given without prior consent of the Central Government. The national security matters remain paramount. The Government of India might take any action including revocation of any patent, which it considered necessary in the interest of security of India.

If one assesses the IPR and its co-relation to India's Atomic Energy Act of 1962, one can easily find a very significant and important area of development. It must be emphasized here that the Atomic Energy Act of 1962 provides for the development, control and use of atomic energy for peaceful purposes. The Act of 1962 has given power to the Government of India to deal with all aspects related to patents and patenting as defined in sub-section (1) of Section 20 of the Atomic Energy Act. This sub-section is cross linked with Section 4 of the Indian Patents Act which states that no patents can be granted in respect of an invention relating to atomic energy falling within sub-section (1) of Section 20 of the Atomic Energy Act of 1962. The inventions relating to atomic energy mean the inventions useful for or relating to the production, control, use or disposal of atomic energy and other relevant methods used in mining, extraction, fabrication, reprocessing and enrichment. It must be pointed out here that the Department of Atomic Energy has immensely benefitted from IP related provisions of the Act, which in a way has helped to achieve adequate success in indigenous development of nuclear science and technology. However, there seems to be lot of challenges in dealing with the dual-use technology in particular from IPR protection point of view.

It is essential that IP related issues of inventions of dual use nature are resolved so that there are no legal hurdles, which might jeopardise emerging commercial interests of India. The relevant clauses of Atomic Energy and the Patents Act may need to be modified in order to take into account the growing needs of commercial interests of the non-nuclear sector. The IPR play a dominant role as an incentive to active and fruitful collaboration in the spin-off experiences from military to civilian sphere and vice-versa. These can provide rich dividends if there are well articulated strategy in dealing with the IPR protection.

In addition to nuclear related dual use inventions, there might be cases and several inventions from DRDO itself that would include both civilian and military applications. The overall

approach to technology development in defence has also been changing. There are a number of areas which are either already outsourced or are being outsourced especially in the field of subsystems of an integrated system.

The R&D in defence basically involves pursuing basic research, applied research, application of results of research, development and transfer of technology. All the ongoing R&D projects mainly aim at creating new intellectual property or develop existing forms of intellectual property. These developments will have lot of critical strategic significance in case of military application. The DRDO should keep promoting those R&D, which would focus on creation of significant intellectual property.

It must be emphasized here that the patent documents become vital for the creation of significant intellectual property. It contains most up to date and latest technological information, which may be used by scientists and researchers when they take up new project for R&D. The use of the patent information by the scientific community will save resources in terms of time and money.

Building Clarity in the IPR issues in Defence Production

The relevance of IPR comes into defence with the Transfer of Technology (ToT).With a developing country like India, ToT usually needs to be imported. Hence targets regarding competing interests and cost acquistions become avenues that IPR needs to explore. Questions related to IPR remain the most challenging at this stage. This is a result of combination of Indian government's efforts to solidify the IPR ecosystem in the country, complying with TRIPS, and at the same time thrusting the agenda for encouraging domestic private players to contribute to Indian defence manufacturing. While in principle this seems complementary, there is a lack of clarity of who will own the IP of these projects.

a. Issue at hand – who should own the IP if government funds the private innovator

This is an important issue not only because in nation's interest, there is a case for the IP of defence equipment to rest with the government, which comes at the cost of diluting incentives to innovate in a sector with expensive R&D, but also because in 'Make' categories, there are provisions for the government to fund the innovation. According to the provisions in 'Buy and Make' with ToT by Indian Production Agencies from OEMs is to encourage domestic industry. However the present guidelines have no contractual provisions outlining management of IPRs related issues. From government-funded R&D-cum-productionization contracts such as "Make" cases or licensing of "DRDO developed technologies ToT" itself is left undefined in terms of

minimum IPRs to be acquired by MoD/IPAs.[193] This makes it even more important to creatively cultivate a policy around the existing laws.

Indian IPR ecosystem is governed by Patents Act 1970, Patent Rules 2003, Trademarks Act 1999, Trademark Rules 2002, Indian Copyrights Act 1957, Design Act 2000, Design Rules 2001, Geographical Indications of Goods (Registration and Protection) Act 1999 and Rules 2002. Indian laws are compliant with TRIPS and the governance architecture is committed to international treaties and conventions related to IPR.

b. Need for an alternative view of IP policy in defence

Given this backdrop, it becomes important to engage with IPR issues related to defence. IPR principles rely on market-based economy in which right on the innovation must lie with the innovator so that her/his incentives to innovate do not dilute. The Preamble to DPP 2016 reminds us however, that defence market cannot be viewed in the same light or scope as another commercial one. This illustrates that creating an alternative understanding of IPR architecture in defence is not only needed, but is also desirable for efficient functioning of perhaps the most crucial sector in national interest.

c. IPR in defence under government's purview

The IDDM category in DPP 2016 is expected to attract huge inflow of funds into the R&D in defence in India.[194] This is complemented by the preference to be accorded to MSME sector in defence, and indeed the thrust of Make in India campaign. Already, there is a Defence Innovators and Industry Association (DIIA) established which seeks to engage with the government to – inter alia – help bring about a policy that encourages IP ownership in Indian companies.[195]

Already, for the Patent application for a product relevant for defence (or atomic energy), there is a mandate for the Controller of Patents to seek written permission from the Central Government before granting the Patent. This brings the idea of IP in defence, already under the government's strict purview.

d. When must government own the IP

Appendix H to Chapter 3 that focuses on 'Make' projects engages with intellectual property. The general idea under 'Make' projects is that the contractor retains the IP, while the government only gets a license. Departure from this contractual default position can be made through

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[193] Yadav, Bhupendra (2016) "Intellectual Property Rights and Defence Production" Defence ProAc http://www.defproac.com/?p=2435

[194] Atluri, Ashok (2016). "India's new Defence Procurement Procedure: Why it is revolutionary," *Indian Express,* 9 February.

[195] Bahadur, Manmohan (2016). "Defence Preparedness: The Way Forward", *the Hindu,* 19 April. Somashekhar, M. (2016). "Defence industry players join hands to promote indigenous R&D," *the Hindu,* 25 February.
See also, www.diia.co.in

provisions mentioned in the Appendix. Section 2 is important; under this, the government through IPMT or any expert or body is allowed to retain full ownership of IPR if it considers the developed technology/equipment to be classified or sensitive and needs to be restricted for use in other purposes or export. The government's standard license rights are termed as 'Government-Purpose Rights' (GPRs), which enable government to 'hold a non-exclusive, non-transferable, irrevocable, paid up (royalty-free) license to practise, or have practiced for on its behalf, the subject invention throughout the world.'[196] Importantly, this is applicable to all subject inventions under the 'Make' contract. A subject invention is any invention of the contractor which is conceived or practiced for the first time under a government contract. It is made clear that GPRs operate at both prime and subcontract levels. After 10 years, the GPRs shall automatically convert to 'Unlimited Rights.' The GPRs include the right to:[197]

i. Use, modify, reproduce, release, perform, display, or disclose technical data within the Government without restriction;

ii. Release or disclose technical data outside the Government and authorise persons to use, modify, reproduce, release, perform, display, or disclose that data for Government purposes

iii. Form, Fit and Function data, which will include Manuals or instructional and training materials for installation, operation, or routine maintenance and repair;

iv. Computer software documentation required to be delivered under the "Make" contract;

v. Changes to computer software furnished to the contractor by the Government;

vi. Computer software that is otherwise publicly available or has been released by the contractor without restrictions (except release due to sale, transfer, or other assignment of interest in the software to another).

The GPRs in computer software allow the right to the government to transfer the software to another government computer, make copies for backup, modify the software, disclose it to service contractors, allow the service contractors to modify the it owing to urgent or tactical situations, and disclosing it to contractors or third-parties for emergency repair and overhaul.[198] GPRs do not entitle the government to use, modify, reproduce, release, perform, display, or disclose technical data for commercial purposes or authorise others to do so.[199]

e. March-In rights – working the patent

[196] Section 5 and 8, Appendix H to Chapter III, DPP 2016.
[197] Section 9 of Appendix H to Chapter III, DPP 2016.
[198] Section 11 of Appendix H to Chapter III, DPP 2016.
[199] Section 10 of Appendix H to Chapter III, DPP 2016.

There is a provision for establishing 'March-In' rights, for all items covered under GPRs. March-in rights include right to work the patent (or get it worked on behalf of the government) if (a) the contractor fails to work the patent on its own within a reasonable, specified time, (b) in public interest, (c) for national security reasons, (d) to meet public use not reasonably satisfied by the contractor, (e) the contractor does not manufacture the product embodying subject invention in India, or (f) the contractor does not comply with requirement(s) laid under the DPP.[200] In general, these rights ensure that government, under broad and reasonable frame, is free to work the patent. Working the patent would mean employing the tools of compulsory licensing, which is allowed under TRIPS and Indian laws have evolved means of employing the utility of compulsory licensing. In defence, the scope becomes broader, for justifiable reasons.

f. Disclosure of all IP by the contractor

Further, the DPP categorically suggests that contractor is bound to disclose in timely manner, all generation of IP under the 'Make' contract to MoD. Failure to either disclose timely or to invoke her right of ownership would mean the IP will slip into the government's hands. Specifics need to be whetted down in the contract. If the contractor does not elect to retain title of any IP, not only will the title will *ab-initio* vest in the government, but also grant government the right to license the IP to the contractor on conditions it deems fit. However, the license so provided would usually be revocable, non-exclusive and royalty-free, extend to its domestic subsidiaries and affiliates, and include the right to sublicense; but transferable only with prior approval of the government.

g. Other Clarifications

For the MSMEs, the new procedure provides them the first right to undertake prototype development up to Rs. 10 crore under the government-funded 'Make' projects. To show which MSMEs would be eligible for the Make programme, DPP 2016 has restricted the participation in such a programme to "only Indian vendors including Association of Persons (AoP)" to be detailed in an appendix that would be notified separately as part of the complete DPP-2016. Pending the release of this crucial appendix, it is believed that entities with majority resident Indian holding would be eligible for 'Make' projects. In other words, Joint Ventures having foreign equity of more than 49 per cent would not be eligible. This would ensure that decision-making and the IPR of the 'Make' designs would stay in the hands of the resident Indians. It is also believed that the eligibility criteria would include a minimum five years of operational experience (three years for MSMEs) besides a credit rating of B++ issued by reputed credit rating agencies.[201]

Report of any commercialization of manufacturing activities under 'Make' contracts must be periodically submitted to the government. The rights of the contractor in these contracts cannot

[200] Section 13 of Appendix H to Chapter III, DPP 2016.
[201] DPP 2016 : An Anayltic Overview, Institute for Defence Studies and Analysis

be absolute in nature and will also be governed by Export Policy, Export Guidelines and all applicable laws, rules, regulations, orders and instructions of the Government of India. All such transfers and exports shall require prior and explicit approval of the Ministry of Defence. And when the DA is dissolved, the IP rights will slide into the government's hand. If the DA is a consortium, depending upon the partnership contract, the rights will be vested among the partners, with no impact on the government's license.

h. Who will address the IP questions?

The primary task of monitoring, reporting and generating of IPR in the context of defence contracts will rest with IPMT, which will consist of representative from SHQ, HQ IDS, DRDO, DDP, DGQA/DGAQA/DGNAI, Advisor (Cost), MoD (Finance)/IFA as required and other experts if considered necessary.[202]

i. Questions related to sharing of IP

A crucial issue in this context is what happens when technology production lies outside 'Make' category. A stylized example is that of the case when a foreign vendor licenses or sells a technology to DRDO, DPSUs or any of their subsidiaries. If and when the buyer (DRDO, DPSU etc. in this case) modifies the technology or augments it using in-house R&D, it installs a claim for the IP of newly formed technology. Note that the vendor could be Indian as well, who has not taken any financial support from DRDO and therefore is rightfully the older of the technology's patent. What happens if, after the technology is sold to DRDO and the latter, after modifying or altering it slightly, wants to patent the new technology. Often this can be a bone of contention between supplier and buyer. The supplier would not want to have a new technology come out of its original technology and not have a share in the new IP. Often, to prevent this from happening, the contracts under which the transaction has taken place, have strong clauses that restrict use of technology to create new IP or for any incremental innovation whatsoever.

This requires a strong intervention on the part of DRDO/DPSUs etc. Since DPP 2016 and other relevant policies are often silent on this aspect, the strategy must take place at the contractual level. During the stage of contract negotiation, DRDO/DPSUs must be able to articulate their strategy and ensure incorporation of clauses that are sympathetic to in-house IP production based on the purchased technology. Exact nature of these articulations will depend on the specificity of technology in question, and will differ from contract to contract.

Certain issues can be clarified at DRDO's level by carving out an *internal policy framework*. For instance, the incremental extent of new technology is crucial. If DRDO adds some value in the purchased technology, its content should be estimated and based on that, IP rights can be negotiated. For instance, if the added technological content is 30% or more, the IP can rest with DRDO. If this is part of an envisaged policy by DRDO (which also mentions adequate

[202] Section 25 of Chapter III, DPP 2016.

flexibility, in order not to discourage a technology provider), the contract drafting can save tremendous amount of negotiation costs. *We strongly recommend DRDO to develop a framework for IP protection of technology that it has built that is based on a technology provided by a foreign firm (or a domestic one which hasn't been financially supported by DRDO).* Such a policy will go a long way not only in plugging the contentious gaps in this respect, but also fulfil valuable need to innovate and hold the right of that innovation. This policy must also build ideas on shared ownership of the new IPR. The framework for shared ownership will depend upon specific contracts, but the idea is to ensure that such possibilities remain open.

Indian Patents Act, 2005 offers tools which can be used to draft that Policy, or recommend negotiating points in such contracts. Few clauses of the Act are particularly useful here.

a) Article 3 identifies an invention, by suggesting what is *not* an invention – invention which is frivolous, contrary to public order or morality, mere discovery, mere admixture, mere rearrangement, method of agriculture, medicinal process, plants and varieties of organisms, mathematical or business method, literary creation, scheme or a rule, presentation of information, topography of integrated circuits, invention based on traditional knowledge. Everything else is an invention, and this idea must be utilized by DRDO in preparing a policy on incremental innovation patents.

b) Article 4 prohibits granting of any patents in an invention relating to atomic energy falling within Section 20 (1) of Atomic Energy Act, 1962, which covers a wide variety of inventions indeed.[203]

c) Articles 54-56 deal with patents of addition, in which patents are allowed to be granted for improvement or modification of an existing patent. The crucial thing however is, that the patent applicant for the patents of addition must be the same party as that of the existing patent. This means that DRDO can possibly apply for patent not in the case of patents of addition, but the entire new technology emerging as a result of its R&D. This is particularly important because the Patents Act 2005 has revised Patents Act 1970, in the crucial aspect of process versus product patents, requiring alternative dimensions of reverse engineering to emerge.

d) Article 35 specifically engages with inventions which are to be kept secret, particularly for defence purposes. These talk about why would certain type of patents warrant secrecy.

[203] Section 20 (1) states, "As from the commencement of this Act, no patents shall be granted for inventions which in the opinion of the Central Government are useful for or relate to the production, control, use or disposal of atomic energy or the prospecting, mining, extraction, production, physical and chemical treatment, fabrication, enrichment, canning or use of any prescribed substance or radioactive substance or the ensuring of safety in atomic energy operations."

Issues related to sharing of intellectual property are enormous. In some sense, it would have been impossible for DPP to capture all important considerations. This would mean that the IP-driven issues will significantly rely on the individual contracts between the government and contractors. This is especially important in cases of Make-I category where government is giving 90% of funding. In cases where government's investments are as high as 90%, there is value in viewing such cases as those which may merit government's sole ownership of IP. In other words, sharing of IP and often-necessary joint ownership must be considered in individual contracts. This requires building a framework for such contracts to be developed.

Conclusion

India has been transforming drastically and in the process of strengthening its manufacturing base with a greater focus on aerospace and defence. If India's aim of becoming a defence exporter has to be realized then it would require calibrating a strategy in a holistic manner. India has established a vast network of institutions in the research and development in defence. The apex institution such as DRDO has to its credit a number of spectacular successes particularly in its missile development and aeronautical system programme. There are a number of other government agencies including the CSIR, the Department of Space and the DST, which are involved in R&D. These institutions do engage with the private sector in a limited manner. The private sector has had a limited share in the R&D space of the defence sector because of the limited collaboration. Now the perception has been changed, where the government is intensifying its efforts to facilitate the private sector and increase their role in defence manufacturing sector. In the emerging scenario a legal and policy framework with a focus on IPR is essential.

The question arises – is India ready and does it have all the essential requisites to move ahead and see that its IPR is protected? Does India have a clarity? What would really constitute the legal and policy framework in the changing dynamics of DPP? It must be emphasized here that the role of private sectors and their investment in the R&D will grow exponentially in the foreseeable future and hence there will be a requirement for a neatly defined ways of protecting IPRs.

There are impediments to the legal recourse because India lacks adequate infrastructure and trained human capital to support the new initiatives where one can identify the contribution in a distinct manner. The other impediment seems to be more serious for the legal recourse because the end users of technology and equipment along with manufacturers are currently not fully involved in the decision making process with key R&D agencies like the DRDO. The existing agencies have not been very successful in sharing R&D capabilities with private players. There are virtually no competition within R&D agencies and private players for developing weapon systems and technologies.

The vision of 'Make in India' has been mainly to achieve self-reliance through building indigenous capabilities for manufacture and maintenance of defence equipment in a cost-effective manner. The pace at which the changes are occurring in India's context demonstrates how the opening of the strategic defence sector for private sector participation will change the dynamics of development. Indian companies would certainly require to bridge the capability gap in the technology and equipment development through partnership with global OEMs by ToT. Such areas would need a comprehensive assessment to find ways and means to accommodate the IPR requirements and its protection.

It must be mentioned here that until now, India has been contracting technology transfers and manufacture under license, which never assisted technological absorption and innovations. The element of IPR becomes dominant when there is some degree of innovation involved in any product. But, the intellectual property rights remained with OEMs and the OEMs were not willing to part with their latest technologies. Hence, the major role of the domestic companies in India has been to do assembly of the major sub systems. If there are certain altercation made in the integration of sub systems into a full system, the questions remain similar with regard to dealing with the protection of IPR regimes.

The OEMs guard their IPRs and they leave nothing for the collaborating partners to add value to the cutting edge technology. The world has been witnessing a number of changes in the practices of guarding IPRs. Since, there are a number of contributors at every level, the IPRs of different parts are held with different partners. Such applicability should be the priority in the Indian industry as well as the production agency.

IPR is contractually mandated deliverables in terms of design, form, fit and function data and other technical documentation. The manufacturer has to take a note of the innovation at every stages of the design and integration of various components. Unfortunately, the guidelines of the DPP do not make it explicit or mandatory requirements for the protection of IPRs. The ToT provisions as discussed in this study elsewhere essentially deals with licensed production based largely on OEM supplied items. It will certainly encourage the domestic companies but at the same time, in the absence of an adequate legal framework, will pose severe challenge to the protection of IPRs.

The same structure applies to the DRDO related R&D in defence, the "Make" cases funded by the government should have a well-articulated well thought out strategy dealing with the IPRs.

To a larger extent, even the MoD subsidized R&D through development contract seems to be silent on the issue whether the IPR ownership will be with the MoD. One can build a hypothetical scenario where the private sector company will develop a subsystem technology under "Make in India" project and the ownership of IP rights will arise. What will happen during a condition when the DRDO will play a dominant role during the initial stages of the project and finally the technology or the subsystem will be developed by the private sector? The DRDO will

keep collaborating with the private player throughout the project. These are few major issues which the MoD in particular needs to pay attention and be explicit in the possession of IPR related issues. The industry does not want to give away or share IPR for technology development by them with the collaboration from MoD in general and the DRDO in particular.

The legal and the policy framework would obviously reflect the gaps between the needs and expectations of the both the partners. While IPR aspects are primarily applicable to hardware related programs, the challenge has also grown and the issues have become further complicated where there is substantial software content also. Hence, the legal framework will help in identifying those nodes of the subsystems so that the IPR is protected. If the joint venture has been engaging in research and development then the IPR should certainly be held with the joint venture.

The IP related issues have to get resolved during the negotiation stage to avoid the legal problems. The policy framework would evolve measures that are required to promote R&D and greater coordination between the research institutes like the DRDO, universities and private industry players. The educational institutions are a rich source of human capital, which can be effectively leveraged to help the overall development in the aerospace and defence sector. There will certainly be immense challenge in developing partnerships between the government and academia or private players because of the lack of confidence in sharing the classified information.

India has the potential and because of the existing policy framework and showing no sign of developing an effective partnership with the private players, the overall capability is yet to be harnessed. There are a large number of niche areas where India has to concentrate and attain a competitive position in developing next generation technologies.

The defence procurement procedure has attempted to a larger extent to define the indigenous content in any product. The method for computation of indigenous content has been well laid down in the DPP. It broadly prescribes the cost of the equipment to be reduced by the cost of imported materials, cost of services received from non-Indian entities at all tiers. The definition of indigenous content in spirit is commendable and seeks to scan through the indigenous content in the entire supply chain. It must be mentioned here that the adherence to the compliance with the requirements at all the levels is going to be extremely challenging for the industry. The challenges to indigenization will remain in the absence a relevant adequate legal and policy framework.

The role of FDI in building a domestic industry and creating an enabling environment for ToT from foreign OEMs cannot be over emphasized. India should articulate a comprehensive guideline to deal with the legal and policy issues relating to the IPR protection in holistic sense.