HEADQUARTERS INTEGRATED DEFENCE STAFF

MINISTRY OF DEFENCE

TECHNOLOGY PERSPECTIVE AND CAPABILITY ROADMAP (TPCR)

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INTRODUCTION

"Our defence forces require timely and cost effective acquisition of defence equipment to enable them to meet any challenge to country's security. If they have to effectively meet these challenges, we must adopt a holistic approach towards defence acquisition right from the planning to final disposal of the weapon system without compromising transparency, fairness and probity at any level."

Shri AK Antony, Hon'ble Raksha Mantri

1. Indian Armed Forces are poised for major modernisation in the next fifteen years. This process would involve upgrades of hardware and systems as well as purchase of new state of art equipment to enable them meet the security challenges in the coming decades; the volumes are high and the financial outlays large. There is substantial scope in the process for Indian industry to harness this market (around US $ 100 billion) to develop indigenous capability; especially in high technology areas.

2. Capacity Building process in the Armed Forces proceeds along a well crafted path. Perspective plans determine the capability sought by the Armed Forces which in-turn drive the procurement of platforms and equipment and the technology required to attain this capability. The plans focus on bridging the capability gaps and building force levels to ensure that the Armed Forces are optimally structured, equipped and weaponised to achieve the desired combat potential across the entire spectrum of conflict.

3. The Armed Forces Long Term Integrated Perspective Plan (LTIPP) covers a period of 15 years. It identifies the shape and size of the Forces over the designated time period based on foreseeable strategic trends. From this document flow the 5 year plans which translate the LTIPP into an action plan with committed funding. These 5 year plans run concurrent with the national 5 year plans. More immediate commitments and capital acquisitions are included in the Annual Acquisition Plans (AAP) to enable effective oversight of committed funding vis-a-vis progress. The unpredictability of the global events in an increasingly 'Flat' world necessitates a periodic review of the Long Term Perspective Plans, which is a continuous exercise. It facilitates mid-course corrections based on discernible emerging trends and the need to adapt to newer technologies. However, the fundamental capabilities enumerated in the 15 Year plan remain essentially the same.

4. The future battle space will be shaped by technology and technological superiority will determine the outcome of future battles. It is therefore essential that technological self-reliance remains the mantra for the future and a collective national effort be initiated to achieve this in the quickest possible time ensuring that technological developments are commensurate with our desired military capability.

5. The importance of being self-reliant in the defence sector needs no emphasis as it is not only of critical strategic and national importance but also an essential component of the national power. In six decades since independence, the country has made significant progress in achieving this goal. However, much remains to be done. MoD recognises that progress needs to be accelerated by harnessing our national capability in all its forms.

6. Indian industry has made rapid strides in recent times. Developing latest technologies, providing state-of-the-art products to the customer and adopting best practices in management has enabled it to not only hold their own in the global arena but also contribute to India's emerging status as an economic powerhouse. This coming of age of the Indian industry must find expression in the defence sector as well. Steps have been initiated through regular interaction between the MoD, individual services and industry and there is a growing consensus on the need for greater industry participation in defence sector. However, the modalities on how to achieve this need to be streamlined and role that both - MoD and the industry has needs to be clearly defined.

7. The MoD has, in the last few years, sought to untangle the cobwebs associated with the Defence Procurement Procedures-2002 (DPP-02). Based on the experience gained and feedback obtained, DPPs have gone through constant iterations through the amendments in 2003, 2005, 2006, 2008, 2009 and 2011. Inputs received from various sources have enabled the MoD to not only simplify the procedures but also address the challenges faced in keeping pace with rapid technological advancement. Defence Procurement Procedure-2013 is currently in force and Para 9(a) has addressed the industry's request for more information to be made available.

8. Development of cutting edge technology having defence application needs considerable investment in terms of time, money and human resource. If Indian industry is to become a participant in the national endeavour of achieving self-reliance in defence equipment, it would have to make this investment. It requires them to be aware of the capabilities the Armed Forces are seeking and the technologies required to achieve these over a reasonable period of time.

9. Induction of new weapon systems is cost and time intensive. Building complex platforms like ships, submarines, tanks and fighter jets has a long lead time which is constantly challenged by the race to keep-up with the relentless march of technology. It is therefore imperative that the long term requirement of capability be identified and understood for appropriate technology to be developed indigenously.

10. The Indian Armed Forces have identified technologies required to be inducted in development of future capability. The Defence Procurement Procedure has articulated the means of obtaining these either through the 'Buy (Indian)', Buy (Global), 'Buy and Make', 'Make' or the newly introduced 'Buy and Make (Indian)' categories. The country has had to perforce resort to 'Buy (Global)' option in the past due to a host of reasons, which has been an expensive proposition. Over-reliance on imported hardware has the potential to

compromise country's defence preparedness in times of crisis, through imposition of various technology denial regimes by the supplier.

11. This document titled "Technology Perspective & Capability Road Map", intends to provide the industry an overview of the direction in which the Armed Forces intend to head in terms of capability over the next 15 years, which in turn would drive the technology in the developmental process. It is based on the LTIPP of the Armed Forces. The document is being put up in the public domain in line with the vision of Shri AK Antony, Raksha Mantri, " ***..to establish a level playing field for the Indian defence industry, both public sector and private sector***." Industry would be expected to interact with the MoD on a regular basis and offer firm commitments in partnering with MoD in developing contemporary and future technologies as well as productionalising equipment required by the Armed Forces. Effective participation based on mutual trust and cooperation would go a long way in achieving the desired degree of self-reliance.

12. The document would be updated periodically as and when further details become available or changes occur in future iterations of Services LTIPP.

CHAPTER 2

TECHNOLOGY PERSPECTIVE

TECHNOLOGY REQUIREMENTS OF INDIAN ARMED FORCES

1. Technology superiority is increasingly going to be the decisive factor in future battles. The development of technology to meet our future joint war fighting should aim at a broad-based programme spanning all defence related sciences. The strategy should be to ensure that we are able to develop and transform superior technology into affordable and critical military capability keeping in mind affordability, timeliness, dual use, technology base and modular design. This would enable the country's R&D establishments to focus on specific capability requirements and work out appropriate technologies needed to fulfil these requirements. It would be possible to identify critical technologies that are likely to be denied and efforts concentrated on indigenous development of these. The focus should be on newly emerging areas of warfare that have been identified as essential for joint war fighting. There would be many capabilities in single service specific areas that are being addressed by respective Services and may need inclusion in future versions of Services' Plan Documents.

2. It is envisaged that R&D Agencies (both Public and Private) would be able to work out a detailed plan to develop the needed technologies, including the necessary funding and their research objectives in specific areas. This would include plans for the development of capability in areas that are considered and draw-up a roadmap towards achieving it by tapping all available national resources including the civilian industry, private as well as government enterprises and the academia.

KEY TECHNOLOGY REQUIREMENTS

3. This section intends to provide the Indian Industry an overview of the Indian Armed Force's common requirement, which in turn should drive research and development in technology.

Battlefield Transparency

4. A combatant must have the ability to continuously look deep, ie, beyond the physical domain of battlefield so as to gain information about his adversary. Future technologies should focus on integration of information obtained from various sensors to enhance situational awareness. This, coupled with smart decision support tools, should lead to information assurance, management, and representation in an easily comprehensible form. Whilst this will lead to effective utilisation of resources, it would also lead to enhanced combat efficiency.

Command and Control Architecture

5. Exploiting battlefield transparency requires real-time, robust, reliable and networked command, control, communications, computers and intelligence

processing systems in order to reduce the decision making time. The development and fielding of automated sensors for various levels of operations and their integration with requisite fool proof communications will provide the much needed force multiplier effect. Adequate redundancy must be built-in into the systems to provide a reliable, fail-safe architecture.

Communication Systems

6. There is a need of integrated platforms to support voice, data, image, multi-media applications and networking. Core and access network hardware must be indigenised. Real-time secure mobile communication links should form the backbone of modern warfare. Smart devices supporting long term evaluation (4G) and mobile satellite terminals with systems and applications supporting indigenous GPS would confer a battle winning advantage. The Armed Forces need supporting architecture and infrastructure towards achieving network centricity. Towards this a defence communication system with encryption with adequate band width is essential. This must also include data linking facilities. Fractal antenna for communication systems would also be required.

Smart Radios

7. The application of digital technology will lead to increasingly intelligent radios. The future should be characterised by robust and high capacity communication networks. Much needs to be invested in the development of Software Defined Radios (SDR) including man-pack versions. These are radios which are reminiscent of computers and will alter their properties according to how they have been programmed.

Information Dominance

8. In the battlefield milieu, information, its integration and conversion into real-time actionable intelligence shall provide the battle winning edge to a Commander. We also need to exploit the electromagnetic spectrum to safeguard own combat systems, intercept and decipher the adversary's information systems in a time bound manner. In addition, we must have the capability to prevent an attack or contain it and affect swift recovery, while at the same time have the ability to target adversary's critical infrastructure and military capabilities.

9. The strategic forces need to be facilitated/ supported by real-time information. These will include satellites that produce sub metric resolution and backed up by UAVs with great staying power in the area of interest.

Electronic Warfare

10. With an unprecedented growth in battlefield electronics, Electronic Warfare will form an integral part of all future conflicts. The problem of jamming and avoiding disruption of one's own systems is going to get complex day-by-day.

Space based EW, remotely controlled and expendable decoys and employment of UAVs for EW would be the norm in the future. Wideband SIGINT, COMINT and EW systems also need to be developed.

Nano-Technology/MEMS

11. Advances in nanotechnology will drive the next paradigm shift in military capabilities. Nano-technology would usher in light weight, strong, multifunctional advanced materials for use in combat systems, while enhancing surveillance, protection and connectivity. Nanotechnology should give rise to new materials which in themselves are multi-functional with entirely new properties. Such materials may reduce power and weight requirements, increase protection of platforms and durability and thereby enhance operational effectiveness of platforms. Carbon composites, metal matrix composites, stealth coatings, self healing materials, adaptive camouflage materials and structures and smart skin materials shall be the main structural materials for the future combat and support systems. Capability for development of Micro Electro Mechanical System (MEMS) based sensors, actuators, RF devices and focal plane arrays would also need to be developed.

Artificial Intelligence and Robotics

12. This technology will introduce parallel soft computing methods like fuzzy logic, neural networking, evidential reasoning and genetic algorithm into photonic or quantum applications. Artificial Intelligence and Robotics shall have the following applications:-

(a) Image interpretation for target identification and classification.

(b) Expert systems for diagnosis and maintenance of sophisticated weapon systems such as radars and missiles.

(c) Robotic equipment can be used to provide precision targeting support and carriage of ammunition and accuracy. Camera equipped and shock-resistant platforms to provide fire power remotely are also possible applications.

Chemical, Biological, Radiological and Nuclear (CBRN) Defence

13. The CBRN defence should include technologies to detect and defeat all kinds of CBRN threats, minimise their lethal effects, develop countermeasures, casualty prevention and management. The defence against CBRN must encompass individual protective equipment, collective protection (both fixed and mobile shelters) and also decontamination systems and equipment.

Miniaturisation

14. As the world moves towards miniaturisation, the benefits from this technology which should lead to development of Microsystems. Microsystem technology should play a key role in development of navigation systems and warhead guidance. This should lead to weapons becoming smaller and more

effective incorporating multiple sensors which work together. Miniature SAR & ISAR technologies also need to be developed.

Unmanned Systems

15. These will also benefit from miniaturisation which will make it possible to design small unmanned vehicles. But the future unmanned vehicle, should become steadily more intelligent. Still further in the future, unmanned vehicles should be capable of working in groups with other vehicles, both unmanned and manned.

Advanced Weapon Systems

16. The Armed Forces must possess weapons of suitable capability to achieve the desired destructions. In today's battlefield, it is essential to minimise collateral damage. The weapons must possess desired accuracy, explosives content to destroy the target while minimising the collateral damage. Weapons catering for counter-insurgency operations, urban warfare, as also normal battlefield operations require diverse approach. The weapons must include both kinetic and non-kinetic weapons capable of producing the desired lethal or non-lethal effects.

(a) **Precision Air-Ground Weapons**. The weapons must have precision capability, and should be capable of independent, reliable and all-weather day or night delivery to achieve CEP of three meters or less. They should be immune to jamming and should not be fully dependent on any ground, air or space based system, thereby rendering them vulnerable to any sort of data blanking by the enemy. They should be capable of independent navigation from release to impact while incorporating the fall back option of pilot in the loop control in the terminal stages. The weapons should be capable of launch and control from independent platforms and capable of trajectory shaping to cater to specific target types. The warheads must be inter-changeable to suit the target types, i.e. blast penetration type, pre-fragmented, pure kinetic energy/ boosted penetration type or general purpose. The weapons should have a beyond visual range, i.e. stand-off launch capability.

(b) **Air-to-Air Weapons**. The air-to-air weapons, i.e. missiles must be capable of beyond visual range launches and should be fire-and-forget. Both active and passive seekers need to be developed. The close combat missiles must incorporate dual seeker capability thereby enhancing their anti-jamming capability and must be capable of full hemispherical launch. This would include missiles with imaging IR seeker heads, which would defeat present day ECM measures. The seeker should have the ability to defeat known infrared counter measures. Cued launch from another airborne platform should be possible.

(c) **Surface-to-Air Weapons (SAMs)**. A vital part of the inventory of any modern day Armed Force, the SAMs are essential for the defence of civil

as well as military assets. Future SAMs should incorporate the latest EW capabilities, coupled with enhanced ranges and accuracy and SSKP of 90% and better. The capabilities of the present missile systems could be improved with better technology for low level quick reaction. Collaborative ventures with other countries would facilitate technology inflow helpful towards future indigenous development.

(d) **Hard Kill Options**. Hard kill options, specifically in the field of anti-radiation weapons need to be inducted both of the air launched and ground launched variety. They must incorporate long on-station time hover capabilities, thereby facilitating fire-and-forget capability.

Electro-Magnetic Pulse (EMP) Weapons

17. Electromagnetic weapons represent both threats and possibilities in the context of network-based defence. The HPM weapon could be used against an opponent's network and become the heavy artillery in the age of network based defence. One useful aspect in the context of operations is that HPM weapons knock out electrical equipment rather than people. In future, HPM weapons may be used to counter incoming anti-ship/anti-aircraft/ anti-tank missiles or to prevent other ships/aircraft from approaching too closely.

Adaptive Warheads

18. In the future battles, all major weapon systems should have highly enhanced accuracy. Research efforts must focus towards the engagement of ballistic missiles. In warhead design, the attempt should be to make it more intelligent, wherein, it must itself be able to select and direct its effects for optimum lethality. A single warhead may also combine a range of different capabilities.

Weapon Guidance

19. Ammunition in future would need to have its own stabilisation and guidance system based on the Global Positioning System. In the absence of GPS, ammunition should be equipped with Inertial Navigation Systems (INS) that includes RLG/FOG with minimal drifts. Such systems should have redundancy built-in and should be difficult to jam. Miniaturising the gyros would also play an important role. Warheads should become increasingly intelligent, to adapt the weapon effects to match the target. They should also blind the enemy's warning and countermeasures systems so that the lethal parts of the warhead reach the target undisturbed.

Space-Based Radars

20. With the advent of digital technology, there needs to be quantum leap in radar technology. There is an increasing trend towards the physical separation of the radar's transmitters and receivers by placing the transmitter in space and the receivers on the ground.

Stealth

21. Stealth technology needs to be developed to minimise detection of own platforms. This could include not only stealthy design features, but also absorbent materials, noise suppressors etc. With stealth technology gaining importance internationally, the reaction time of our own military sensors must be improved as the permissible target detection time would become shorter. Target tracking and guidance radars must respond more rapidly, otherwise the weapon systems will be unable to engage the targets.

Digital Systems

22. Digital systems have revolutionised radio and radar systems. Digital radar can achieve resolutions in centimetres and low frequencies can be used to detect stealth aircraft. Capability also needs to be developed for low power dissipating high capacity digital computing elements. Also needed are advanced DSP techniques and hardware design.

Adaptive Antenna Signatures

23. Future smart antenna systems should consist of electrically controlled active antennae that can handle a number of different targets at the same time. Future antennae should be able to control their own signatures to avoid detection. Such antennae will have greatly increased capabilities which would be based on constantly improved and refined subsystems and individual components. Common aerial working systems also need to be developed to remove top deck clutter on ships.

SAGW

24. Air Defence in Vulnerable Areas requires to be strengthened. The number of VAs and VPs that need to be protected would continue to increase over the years. Their protection will require augmentation of SAGW. Air Defence and weapon locating radars to provide cover over the Tactical Battle Area would also be critical component of maneuver warfare.

Sensors

25. While India has performed commendably in the field of space-borne sensors, the indigenous expertise in the field of airborne sensors still remains low. Similarly, fundamental knowledge in the field of radars, electro-optical and IR sensors has been good, but translation of this knowledge into military systems has not been adequate. In the future, the operational capability of the Armed Forces would depend to a great extent on the capabilities of its targeting systems and precision weapons. It is envisaged that the R&D organisations and the Industry would invest more towards evolving sensor technologies and even more importantly towards managing projects that would ensure availability of world class systems. The critical sensor technologies would be:-

(a) Advanced EO and IR sensors with optical correlation and IR imaging capabilities for targeting and weapon seekers.

(b) Emerging radar technologies such as AESA (Active Electronically Scanned Array) Radar with multi-mode capabilities and Non-Cooperative Target Recognition (NCTR) facility.

(c) Synthetic Aperture Radar (SAR) and Inverse SAR (ISAR) capabilities with enhanced processing features and capabilities.

(d) Development of High Frequency Surface Wave Radar and Low Probability of Intercept (LPI) radars.

(e) LASER based systems for detection and imaging of targets.

(f) Night vision devices incorporating state-of-the-art thermal imaging technology.

(g) Ground based sensors, both attended and unattended.

Sensor Fusion

26. The amount of information available today to any operator, be it the man at the launch pad of a SAM or a pilot in the cockpit of the latest fighter, is overwhelming. With a plethora of sensors available and providing information, there is a need for proper sensor fusion, to ensure that only the relevant data is provided to the operator in the appropriate form, facilitating timely and correct decision-making. There is the need to improve the quality and the filtering of the data through a centralised agency for appropriate action by the operators.

AVIATION

27. Enabling the aviation arm of the Services to effectively support the entire gamut of surveillance tasks, integral combat ops, offensive missions in all the three dimensions would require to be well supported by futuristic technologies. It would include various systems required for aircraft such as propulsion, avionics, nav-attack systems, radar technology, airframe structures, Electronic Warfare etc. The future technology imperatives in this group are enumerated in the succeeding paragraphs.

Aircraft Structures

28. In the short term, increasing use of composites should be encouraged. The knowledge gained with indigenous development programme should be utilised for the future projects. Platform design and employment of advanced

CFD tools in the field of Finite Element Analysis and structural optimisation are required.

Propulsion Technology

29. Although, there has been a gap between indigenous developments / capabilities and the capabilities of aeronautically advanced nations in the field of air breathing engines, the industry must intensify its collaborative ventures to leapfrog and catch-up in this field. The Indian Armed Forces require high performance turbo fan engines for their fighter and transport fleet. The next generation fighter aircraft should invariably have three-dimensional thrust vectored nozzles. Development of variable bypass engine would need to be commenced within the next ten years. Fundamental engine technologies such as single crystal blade design, high temperature materials, combustion chamber design, and CFD programs should evolve between the short and mid terms.

30. **Engine Systems**. All the aircraft engines must incorporate Full Authority Digital Engine Control (FADEC) systems, with full manual back up. This will facilitate more fuel-efficient and surge resistant engine operations.

Avionics

31. The technology of core avionics display systems and their software has been witnessing a rate of growth higher than other related fields. Indigenous capabilities in the field of avionics such as mission computer, display processors etc, have already been noteworthy and all efforts should be made to ensure that we remain contemporary in this field.

(a) **Display Systems**. There would be a requirement to impart greater impetus to the development of display technologies such as optical thin films, thin TFTs, collimators for wide angle holographic HUDs, head/ helmet mounted sighting systems and head level or head down displays. The technology absorbed through ToTs for the display systems of various aircraft and integration of helmet-mounted display system should form the foundation for future developments. All aircraft must incorporate Smart electronic displays, which can be easily re-configured as the situation demands. The Multi-Function Displays (MFDs) must be capable of overlaying and displaying a variety of data from a multitude of sensors, with suitable clarity and resolution. In addition, the Mission Computers (MC) and Digital Map Generators (DMGs), which will be a part of the entire package, must be capable of providing a 3-dimensional image of the terrain over-flown along with enemy radar ORBATS displayed, thereby facilitating independent fly-through capability by the aircraft. The MCs must be reliable, Electro-Magnetic Pulse (EMP) proof, dual-redundant and capable of independent operation in the event of one MC failure. Furthermore, the MC must have sufficient memory capacity and RAM to facilitate taking on tasks that the situations would demand.

(b) **Navigation Capability**. All the platforms should have an independent, jam proof, reliable and redundant navigation capability. The navigation systems must incorporate the ability for feeding the mission from a portable data loader and within the next decade must be capable of uploading the mission directly from the ground via the data link. In addition, the navigation systems must be coupled with recovery aids like VOR/ILS and TACAN for all fixed and rotary wing aircraft, to facilitate safe aircraft launch and recovery under adverse weather conditions. These aids will also aid in other aircraft missions like Air-to-Air Refuelling. Corresponding ground infrastructure would also need to be developed and inducted.

(c) **Auto-Pilot**. All aircraft must incorporate advanced autopilots, which must include all modes of horizontal and vertical navigation and aircraft recovery linked to the aircraft Flight Management System (FMS). Depending on the aircraft role, it must incorporate Terrain Following (TF), height recovery, approach, aircraft automatic recovery and horizon/ wings level modes etc.

(d) Airborne sensors including UAVs operating at high and medium attitudes with extended endurance periods, capable of withstanding adverse conditions like high winds or jet stream phenomenon.

(e) **Night/All-weather Capability**. All the aerial platforms must possess suitable night vision and all-weather capabilities. This translates into the platforms possessing the necessary systems, facilitating full mission operability with devices such as NVGs (Fourth Gen) and IR systems like next generation FLIRs.

32. **Flight Control Systems**. All the aircraft of the future, be it fighter, transport or helicopters will necessarily have Fly-By-Wire/ Fly-By-Optics Technologies. Presently, already incorporated on most fighters, they must all be full authority, multi-redundant systems and battle hardy, enabling recovery even in the event of multiple channel failure. In the case of helicopters, incorporation of these flight systems would be focused on the medium term perspective.

33. **Aircraft Safety Systems**. Aircraft safety systems, akin to Traffic Collision Avoidance System (TCAS) and Enhanced Ground Proximity Warning Systems (EGPWS) must be incorporated, with the facility being available to the pilot to disable the system for any specific mission. In addition, all aircraft would need to incorporate Reduced Vertical Separation Minima (RVSM) capability, as all aircraft operating above FL 150 need to be RVSM compliant.

34. **Aircraft Survivability**. Develop technologies to enhance aircraft survivability including multi-spectral signature control, active / passive vulnerability reduction technologies, damage-tolerant aircraft structures; defensive avionics and counter SAM capabilities, including missile and laser warning systems, expendables, and passive and active countermeasures; defence against MANPADS; and multi-spectral threat warning. The aircraft must

be capable of surviving battle damage and there must be sufficient redundancy in all critical aircraft systems, facilitating positive aircraft recovery and, if possible, mission accomplishment even in the event of a dual system failure.

35. **Data Linking/Transfer**. In the dense and technology intense battlefield of today, situational awareness is of paramount importance. Therein, the provision of rapid, near real-time data acquires critical importance. All airborne platforms thereby must have the facility for secure data linking for the real-time transfer of data between themselves and also with any ground-based agency. In addition, considering the varied nature of the Indian Armed Force's ground and airborne fleet, commonality of the data linking abilities is essential.

36. **Information Operations (Low-cost Computer Network Monitoring Capability)**. Airborne network attack capabilities; improved communication network exploitation, including jamming.

37. **Electronic Attack**. Develop airborne sensors to detect hostile electronic emissions with improved noise and deceptive jamming capabilities. These sensors would need to incorporate better techniques, more power, improved reaction, increased performance in dense threat environments and broader spectrum coverage. Develop airborne EA technologies that can effectively deceive or degrade advanced search and tracking radars, effectively disrupt modern communication and data links (both conventional, military and asymmetric) and disrupt asymmetric, non-traditional targets such as RF triggering devices. The aim should be to achieve reduced cockpit workload and automated signal correlation.

38. **Information Electronic Warfare (IEW) Systems**. Modern day RWRs giving high detection ranges of up to 200 km need to be inducted on all aircraft. Furthermore, for platforms capable of undertaking the hard-kill option against ground emitters; the technology of HADF (High Accuracy Direction Finder) must be incorporated, capable of providing very high angular detection resolution, facilitating identification of specific emitters even in a cluster of emitters. RWRs must operate over the full range of the utilised electronic spectrum. Due to loosely guarded proliferation, availability of shoulder fired IR guided SAMs even with small time insurgents cannot be ruled out. It is essential for all airborne platforms to be integrated with MAWS (Missile Approach Warning Systems) and LWS (Laser Warning Systems). Coupled with the detection capability the possibility of incorporating a workable Directed Infrared Countermeasure (DIRCM) system must be considered.

39. **Persistent Target Detection**. Develop technologies to detect, identify and track surface combatants in all-weather conditions, in both day and night operations, over long standoff ranges (beyond projected surface threat envelopes). The systems should have high probability of mission kill and low probability of collateral damage, to support the engagement of surface combatants, landing craft, and other high value surface assets in the most challenging scenarios.

40. **Target Identification and Discrimination**. Develop technologies to enable automatic detection and discrimination of small targets (eg. periscope) from all altitudes and/or standoff ranges, and improve active/passive/multi-static identification algorithms to minimise false targets.

41. **Anti Air Warfare**. Develop targeting, engagement systems and weapons technologies to detect, track, identify, and engage advanced air threats outside of their projected sensor ranges and the kinematic range of emerging missiles in an Electronic Attack environment.

42. **Strike Missions**. Develop technologies that enable all-weather endurance over a large area of responsibility and neutralisation of a range of time critical targets over multiple locations, including maritime and all types of shore targets in the most challenging scenarios, with little collateral damage.

43. **Enhancing Legacy Weapons**. Enhance capability of legacy weapons and armament to provide improved ranges, ability to be deployed in all-weather conditions and precision attack.

44. **Support to Missions**. Develop technologies that permit new missions to be rapidly planned and ongoing missions to receive flexible logistic support in response to unanticipated changes in the operational tempo. Integrate operational, maintenance, and logistic planning and distribution systems to reduce or eliminate the operational pause and enable persistent combat operations.

45. **Communication and Networks**. Develop technologies to improve aircraft communications and network connectivity performance (speed, range, observability, communications) throughout the battle space. The communications should cover a large band width and provide a high data rate for voice, data, and imagery and video transmissions. There should be a high level of network security with encryption / decryption capability.

46. **Safety, Availability and Affordability**. Develop, integrate and transition technologies to improve system safety, increase availability, extend useable service life, and reduce maintenance actions and environmental impact on operations, basing and training. Develop and implement methods and technologies that predict and identify performance problems, reduce the development, support, maintenance and acquisition costs of systems, including air platforms, weapons, training systems and aircraft carriers. Niche technologies like solid-state technology and Gallium Nitrate T/R modules must be utilised for enhanced system effectiveness.

47. **Training**. Development of full-motion aircraft simulators for existing and future aircraft inductions, rear cockpit trainers for mission training, aero-engines and aircraft system simulators for technicians to provide better and realistic training.

UAVs

48. The future UAVs should be smaller and easier to transport and have the following essential features:-

(a) The size as well as modern stealth technology should make them difficult to detect. They should also be able to make own assessment of the surroundings and use it as a basis for autonomous smart decisions relating to, for example, its choice of route and the use of sensors.

(b) Develop technologies to enable unmanned, highly autonomous strike capabilities against the full spectrum of potential targets. Flexibility of UAVs to operate from multiple platforms would rationalise manning and financial effects. In addition, control of multiple UAV platforms from remote locations would incorporate flexibility in basing and operational deployment. Automated flight control and take off/landing systems are desired to enhance redundancy.

(c) The pay load and sensors need to be upgraded with changing technology. The future of the military aviation is moving towards the unmanned sector capable of undertaking multiple tasks. Capable of extended loiter times, it would provide a continuous flow of desired information to the pilot through the sensor fusion of all data automatically onboard. In the medium term, with the increase in the computing power onboard the UAVs, there would be a gradual shift towards greater utilisation of these vehicles in all spheres of military operation. It is desirable that indigenous development, as well as collaborative ventures for future generation UAVs must be intensified now in order to have a credible capability.

49. **Long Endurance UAVs**.

(a) **High Altitude Long Endurance (HALE) UAVs**. The Armed Forces require HALE UAVs having all-weather capability to operate at altitudes of 36,000-65,000 ft with endurance for a minimum endurance of 96 hrs with a payload upto 1500 lbs.

(b) **Medium Altitude Long Endurance (MALE) UAVs**. The MALE UAVs required should have all-weather capability to operate at altitudes of 25,000-36,000 ft with endurance of 36-48 hrs at a cruising speed of atleast 90 knots.

50. **Tactical UAVs**. UAVs, operating up to a maximum altitude of 15000 ft and having an endurance of 24 Hrs with a payload of IR/EO sensors.

51. **Mini/ Micro UAVs**. These may be hand-launched UAVs in the weight category less than 30 kgs and should have a min endurance upto 120 mins.

52. **VTOL UAVs**. The Vertical Take-Off and Landing (VTOL) UAVs should have the capability to carry a payload of upto 2000 lbs, endurance upto 12 hrs and a range of atleast 100 nm. The payloads should include a Synthetic Aperture Radar (SAR), EO/IR sensors, communication relay, COMINT, SIGINT, ELINT payloads.

53. **Unmanned Combat Air Vehicles (UCAVs)**. Unmanned vehicles capable of engaging targets are already on the anvil. Technologies to provide the UAVs with light weight weapons having precision strike capability would provide operational flexibility. The UCAVs should evolve into full mission capable platforms, with the ability to carry and release precision guided munitions. These would minimise collateral damage which will be an important criteria in all future conflicts. These weapons should have a CEP of 3 metres or less.

Aerostats

54. A less costly alternative for surveillance and communication needs that has emerged is a high altitude Aerostat. In future, instead of the anchored systems, we could think of mobile Aerostats. It is also possible to have a smaller system of aerostats, which act as communication relay facility for a network of sensors. Also, Aerostats with Electronic Intelligence (ELINT) and Communication Intelligence (COMINT) payloads are essential.

Aerospace

55. **Satellites**. With miniaturisation, the future trends should be towards smaller satellites. In fact, a network of satellites capable of working together should be capable of seeing a moving target on the ground or at sea anywhere in the world. With the advent of anti-satellite weapons (ASAT) a concept of 'watchdog satellites' to guard other satellites could also be explored.

56. Satellites are being utilised for meeting reconnaissance, surveillance, meteorological, navigation, SAR and communication requirements. New programmes are required to encompass growing needs of data-intensive modern weapon systems. Areas that merit special concern are:-

(a) **Communications**. SATCOM would be the conjoint medium using technology for broadband communication. Such a system is to also cater for critical redundancies (during contingency).

(b) **Meteorology**. Geo-stationary satellite and constellation of LEO satellites for near real-time high resolution weather data are required. Data processing facility within IAF for processing Met data from KALPANA, INSAT 3D, OCEANSAT and MEGHA TROPIQUE meteorology satellites and generating various meteorological products would be required for weather forecasting.

(c) Satellites with improved sensors, resolution and revisit schedules.

Environment Friendly Technologies

57. The Indian Armed Forces have adopted innovative approaches to reduce the carbon footprint and promote eco-friendly systems in establishments and environment friendly technologies to conserve nature. The Armed Forces are looking for eco-friendly solar, wind and electric power and propulsion systems as well as Hybrid Marine Power (HMP) systems (for the maritime domain) which are capable of lowering fuel consumption, reduce pollution and better energy efficient while helping vessels to operate quietly.

LAND WARFARE

58. An overview of technology requirements for land warfare to achieve the desired capabilities are covered in the succeeding paragraphs. The requirements are dynamic in nature and be viewed as an indicative guide only.

59. **Future Combat Systems**. The future combat systems including battle tanks and infantry combat vehicles must be highly maneuverable and have enhanced protection against various forms of threats, namely, tanks, anti-tank guided missiles, armed attack helicopters and anti-armour mines. Other technologies which are necessitated so as to enhance the vital ingredients of mobility, lethality and survivability are:-

(a) **Mobility**. Compact power packs and electro mechanical drives and advanced suspension systems remain the primary concerns. The platform be capable of operating not only on land but also have an amphibious capability.

(b) **Lethality**. The imperative are:-

(i) Development of electronic guns exceeding muzzle velocities of conventional tubes.

(ii) High velocity Kinetic Energy ammunition along with chemical, High Explosive Anti Tank and thermo-baric munitions/missiles.

(iii) Trajectory Correction munitions systems that would provide enhanced accuracy and lethality.

(iv) Advanced fire control systems.

(c) **Survivability**. Smaller and more compact armoured vehicles coupled with effective signature management to enhance survivability along with protection and counter-measure systems.

60. **Guns, Rockets and Missile Systems**. The need is for long range systems with higher accuracies and lethality. Radar based Trajectory Correction Systems

with inertial navigation systems remain essential features. Anti-missile active and passive seeker defence technologies for supersonic cruise missiles, short range missiles and long range sub-sonic cruise missiles are also sought.

61. **Robotics**. Robots to assist troops in combat for tasks such as surveillance, reconnaissance, anti mine and anti IED role, urban area combat and casualty extraction etc.

62. **Bio-Technology**. The bio-technological R&D should be extended to development of biodegradable ammunition which causes minimum damage to the environment, lighter food and fuel for carriage by individual combatants, and bio production mechanisms to enable soldiers to generate food, fuel and materials from raw materials in the field, allowing for extended operation in remote areas.

63. **Non - Lethal Weapons**. Sub-lethal or disabling military technology suitable in an urban or complex environment. Important areas of research in this field could be:-

(a) **Stun Grenades**. Low impact grenades which can stun or immobilise adversaries.

(b) **Optical Weapons**. Optical munitions to cripple sensors and dazzle, if not blind, soldiers.

(c) **Acoustic Weapons**. Weapons that emit sonic frequencies to cause sensations as disorientation, debilitating dizziness and motion sickness or nausea, as also generating vibrations of body organs, resulting in extreme pain or seizures.

MARITIME

64. The full range of operations in which a nation's maritime forces may be involved is extremely wide, including high intensity war fighting at one extreme and disaster relief operations at the other. This broad range of operations can be broken into distinct roles each demanding a specific approach to conduct of operations (Military, Diplomatic, Constabulary and Benign Roles). Based on these, the capability road map is drawn up. Apart from the technologies listed above, the technologies required by the Indian Armed Forces in the maritime domain are appended in the succeeding paragraphs.

65. Technology for development of following capabilities would be significant for maritime warfare:-

(a) Ship launched / recovered UAVs and UCAVs with integrated radars/IR/LASER/video surveillance system.

(b) LASER based wake detection capability.

(c) Low frequency transducers for underwater detection.

(d) Surface-to-Subsurface strike capabilities comprising development of long, short and medium range super-cavitating torpedoes, with active homing heads.

(e) Development of ship fitted guns and mountings with limited surface attack capability to engage unarmed merchant shipping, beach softening, Anti Air Defence, Including the CIWS gun mounts capable of engaging the low flying sea skimming missiles, with Fire Control Systems for target acquisition and target identification.

(f) Improved ammunition with limited precision guidance for increasing the range and lethality of SR/MR guns.

(g) Towed array, variable depth and seabed surveillance sonar systems.

(h) Development of higher accuracy RLG based INS systems.

66. **Laser Communications**. Laser communications could be adopted in future to achieve two-way real-time communications with submarines at operational depths. This technology would also offer exchange of data at very high rate.

67. **Amphibious Aircraft**. These need to be developed for missions like intelligence gathering, HADR, SAR, logistics and communication duties in fleet support, along with conventional aircraft carrier.

68. **Unmanned Underwater Vehicles (UUVs)**. Technology in the field of unmanned vehicles can also be used to develop UUVs which could be used as small, high-speed submarine hunters. Mine clearance would be another suitable application for them. The next generation of submarines could carry a number of UUVs capable of penetrating shallow rivers or canals while the mother submarine lies safely out in deeper water. The UUVs could also be used as forward sensors, as a means to detect minefields or as weapon carriers.

69. **Underwater Surveillance**. The thrust in future should be towards development of advanced sonars. In the longer term, it may be possible to depict objects in three dimensions using laser technology. Underwater radar for close range surveillance is also being considered by some advanced navies.

70. **Airborne ASW**. Improved underwater multi-spectral detection, localisation, and identification with an emphasis on passive methods; remote interrogation and propagation of unattended ASW sensor fields; and improved data-link capability for sharing ASW information and data with submarines and surface ships.

71. **Air-Launched Weapon against Undersea Threats**. Develop advanced precision delivery ASW weapons for all-altitude attack of target at any depth and at long ranges with high success criteria. The weapons would need to be light-weight, perform engagements at high speeds and be equipped with intelligence, loiter and self detection capabilities.

72. **Training**. Development of simulators and 3D walk-through model of ships using virtual reality to provide ship's crew better and realistic training.

73. **Tethered and Expendable Buoy**. This technology needs to be developed to achieve tactical communications with underwater platforms.

Marine Engineering

74. Major equipment and systems such as propulsion plants, prime-movers for power generation, air conditioning and refrigeration plants employed onboard ships need to be specifically designed for marine application or "marinised" from commercial models.

75. Engineering equipment have been broadly tabulated into following categories for highlighting the requirements:-

(a) Main Propulsion Equipment.

(b) Prime Movers for Power Generation Equipment.

(c) Auxiliary Equipment.

(d) Machinery Control Systems/Equipment.

(e) Miscellaneous Equipment

76. **Gas Turbines.** Gas turbines, in the range of 11-15 MW and 20-25 MW are required for fitment onboard future ships as main propulsion units. Presently, all gas turbines fitted in naval ships are of foreign origin. There is an urgent need to develop indigenous gas turbines.

77. **Diesel Engines.** Diesel engines in the range of 1-7 MW are used as main propulsion units. The primary requirement is for low noise levels, high availability and reliability. Indigenous manufacture / development of high power diesel engines to naval specifications will greatly reduce our dependence on imports. In addition to above the following specific requirements also exist:-

(a) **Motor Boat Engines.** The Survey motor Boats (SMB) and the Rigid Inflatable Boats (RIBs) are powered by diesel engines in the power range of 100-250 HP. These engines are required to be lightweight and rugged in design and having a high Mean Time between Overhaul / Failures (MTBO/MTBF). The survey motorboats are operated at sea for 8 to 10 hours continuously.

(b) **Non Magnetic Engines**. The minesweeping vessels are fitted with non-magnetic 250HP engines. Presently, no indigenous diesel engine manufacturer is manufacturing non-magnetic engines. Indigenous manufacturers could enter into strategic tie-ups with reputed foreign manufacturers of Non Magnetic diesel engines to develop indigenous competence and capability in this field for meeting requirements of the Navy.

78. **Gearbox**. Gearbox generated noise is a major factor in the overall under water noise signature of ship. Indigenous development of ultra low noise gearbox to achieve quieter operations is the need of the hour.

Prime Movers for Generators

79. **Diesel Engines, Steam Turbines and Gas Turbine Prime Movers**. Indigenous development / licensed production of diesel engine and gas turbine prime movers in the higher power range (1 to 3 MW) will enable import substitution and also provide prompt and reliable product support for the Navy.

Machinery Control Systems

80. **Machinery Control Systems**. The design of all machinery control systems for future shipbuilding programmes are being evolved around open architecture standards. This will ensure indigenous availability of core hardware as well as software of machinery controls on all new construction ships. For existing ships, conversion to indigenous equivalent designs have been planned for a few class of ships in the next 10 years and identification of suitable designs is in progress.

81. **Engineering Instrumentation**. DME Specifications have been formulated for indigenisation and standardisation of all engineering instrumentation (Pressure gauges, 4-20mA gauges, pressure / temperature switches etc). Compliance to DME specs is mandatory for supplying instrumentation for the new construction ships and progressive replacement of the imported instrumentation-fit for the ships in commission.

Auxiliary Equipment

82. **Shafting/ Controllable Pitch Propellers (CPP)**. At present, some headway has been made in indigenous development of Fixed Pitch Propeller shafting systems with foreign collaboration where the critical components such as Propeller, Stern Tube Bushes, 'A' Bracket Bushes, Plummer Block bearings are still being imported. There is need to indigenously develop CPP shafting systems with a greater indigenous content of critical components for the future indigenous ship construction projects.

83. **Propeller Shaft Sealing Arrangements**. Shaft sealing devices are required to prevent ingress of seawater through the stern tube. At present, these shaft seals are being imported from foreign firms viz. Deep Sea Seals, UK etc.

There is a need to develop reliable indigenous gland sealing arrangement for the shafting system of the new construction ships and also for replacing the imported assemblies installed on existing ships as and when due for renewal.

84. **Stabilisers/Steering Gears.** These constitute hydraulically powered stabilizers / steering systems with digital controls adapted for Naval warship applications. The systems include high pressure hydraulics including variable delivery pumps, hydraulic manipulators and rams having predominantly high precision high reliability hydraulic components. Presently, all critical hydraulic items (hydraulic pumps & control valves etc) and controls are being imported. Indigenous expertise in this field is yet to consolidate and may be facilitated by technical tie-ups with reputed foreign manufacturers.

85. **Propulsion System Integration.** Naval ships are powered with suitable propulsion plants to meet the specified targets of speed, endurance, and maneuverability as per their envisaged roles. The propulsion plant could consist of a Diesel Engine, Gas or Steam Turbine or combination of these. In-depth studies are required for selection and integration of the Prime Mover, Gearbox and shafting arrangement for evolving an effective propulsion system to match ship's hull and tonnage. The propulsion system design and integration studies are presently being sub-contracted to foreign ship designers and vendors. With a large number of indigenous shipbuilding programmes envisaged in the future, there is a need for the Indian industry to acquire adequate expertise and in-house competence in propulsion system machinery selection, design and integration studies. Diesel-electric propulsion of ships and Integrated Electric Propulsion Generator are such critical areas where the technology needs to be harnessed by the industry in future.

86. **Air Conditioning and Refrigeration Plants.** Air conditioning plants in the navy range from 30 tons to 500 tons capacity. Although Indian manufacturers are capable of supplying the higher range AC plants, the import content for such plants is in the order of 50-70%. Also, in the light of IMO regulations for phasing out of ozone depleting CFCs, there is requirement to convert existing R-11 plants to operate on R- 22 refrigerant. Indigenous industry has a large role to play in developing associated technologies for converting AC plants to run on R-22 / non-CFC based refrigerants. Also, there is a requirement to indigenously develop screw compressors for higher capacity AC plants.

87. **Air Conditioning and Ventilation Systems for Ships**. The Navy has now transformed from the earlier conventional change-over system to a much more secure and advanced methodology of TACS (Total Atmospheric Control System). A TACS system ship is always under an over pressure as compared to the atmosphere and air is constantly being supplied through Air Filtration Units. Whilst the HVAC system is designed by IN design organization, the need of the hour is to have indigenous vendors who are capable of carrying out the HVAC design implementation on turn-key basis onboard IN ships, which necessarily involves the work on trunkings, installation, trials, commissioning, proving of system and post-commissioning support. The scope of work also involves interfacing HVAC with the ship's chilled water system. The HVAC equipment

manufacturers should introduce modern technologies while also evolving compactness in size and reduction in weight.

88. **HP Air Compressors.** Air Compressors are employed onboard for variety of requirements. The capacity, pressure and quality of discharged air is dependent on the end use. There exists a large inventory of Soviet origin compressors of varying discharge pressure (200 to 400 bar) and capacity (upto 100 cubic mt / hour) and there is ample scope for indigenous substitution in this field.

89. **Control Air Compressors.** In order to provide oil and moisture-free air required for operation of machinery controls, servo air compressors of import origin are fitted onboard various ships. Ample scope exists for indigenous manufacturers to meet the requirements of new construction ships and replacement of imported compressors for ships in commission.

90. **Desalination and RO Plants.** All marine vessels, large and small, require equipment for producing potable water for domestic consumption. In addition, there is also a requirement of desalination plants to produce high purity water with maximum chloride content of 1 PPM for use as boiler feed water, aircraft services and battery fluid for submarine batteries. The Reverse Osmosis plants are being procured from a single indigenous source, which also has large import content. There is a requirement to develop additional indigenous sources of supply of the RO plants with considerable reduction in import content.

91. **Centrifuges.** A large number of Russian Origin Lube Oil and Fuel centrifuges are presently in use onboard ships. Efforts need to be put to identify/ develop indigenous sources for manufacturing of lube oil centrifuges of capacity 1000 to 4000 litres per hour as replacement for Soviet-origin centrifuges.

92. **Centrifugal Pumps.** Fire pumps, AC and Ref plant seawater pumps, dewatering pumps, and fresh water pumps of Russian origin are fitted on ships. These pumps are of discharge pressure ranging from 2 kgf/cm² to 12 kgf/cm² and capacity 10 tons per hour to 250 tons per hour. Indigenous substitutes of these pumps are being developed through reputed Indian pump manufacturers. The volumes involved are quite substantial and should prove attractive for more Indian industry players to venture and meet the growing demands for new construction ships and replacement for imported pumps on existing ships.

93. **Gear/ Screw Type Pumps.** Gear and Screw pumps are widely used onboard for conveying POLs and combustible fluids due to their less turbulent pumping action. Given the large numbers and diversity of the pumps, there is ample scope for manufacturers to venture in this field.

94. **HP Air and Hydraulic System Valves.** Air and hydraulic system valves for high-pressure application (up to 400 bar) are not available indigenously and are being imported from UK and Russia for all the indigenous shipbuilding projects. These could be taken up for development by Indian valve manufacturers.

95. **Sea Water System Valves**. Sea water system valves are widely used in the critical systems of ships. There is a recurring demand for valves in large numbers of sizes 25 mm to 250 mm. Navy has specified Nickel Aluminium Bronze (NAB) valves for sea water systems. This relatively low technology but high volume field presents an attractive opportunity for the industry to step-in and supply reliable and quality products for Navy's current and future requirements.

Miscellaneous Equipment

96. **Fire Fighters Thermal Imaging Camera**. Thermal Imaging Cameras (TICs) are used onboard ships by Fire Fighters for locating the source of fire in smoke-filled compartments and also to locate trapped personnel. Presently, Thermal Imaging Cameras are being imported and there is a requirement to develop them indigenously.

97. **Canned Motor Pumps**. Owing to advantages like high MTBO/MTBF, low noise and compact size, leak-free and virtually nil maintenance, IN is considering the induction of Canned Motor Pumps for new construction ships and as a replacement of existing centrifugal pumps onboard the ships in commission. The requirement would be from 02Kgf/Cm2 to 12Kgf/Cm2 and capacity 02 TPH to 250 TPH. Ample scope exits for pump manufacturers in this field.

98. **Magnetic Bearing Compressors AC Plant**. In pursuance to the Navy's endeavour to induct low ABN/SBN and high MTBO equipment, IN is considering the induction of magnetic bearing compressor chillers (AC plants), using environment friendly 134A (non CFC) refrigerants for new construction ships and existing platforms as replacement of conventional AC plants from 60TR to 250TR capacity. Ample scope exists for AC plant suppliers providing solution on this contemporary technology based equipment with long term product support perspective.

99. **Screw Compressors**. The AC compressors are all traditionally reciprocating type and maintenance intensive. AC plants with screw compressors have now been inducted on new construction ships and as replacement of reciprocating compressors on existing ships due to advantages of low SBN/ABN levels and high MTBO. There is ample scope of AC plants with screw compressors in capacity range of 40 TR to 200 TR.

100. **Protective Suits**. The Navy has a requirement of Nuclear, Biological, Chemical protective suits for use by personnel in a CBRN environment. The suits should be of reusable type with preferably, spherical carbon absorbed based technology. Also suits with non-woven / woven carbon fibres are acceptable subject to the condition that they meet all user requirements. Presently, only the DRDO is in the process of developing re-usable suits. Indigenous manufacture of the suits with technical collaboration from established manufacturers would serve the large requirements of all the three services.

101. **Fire Fighters Protective Clothing**. There is a requirement to develop Nomex based fire fighters approach suits for use onboard ships during fire

fighting operations. The Nomex based protective suit should meet the Naval requirements, which are based on EN 469, an International Standard for fire protective clothing.

102. **Acoustic Enclosures.** With increasing emphasis on stealth, Navy is engaged in finding ways and means to attenuate the radiated noise levels. Acoustic enclosures are one of the ways to suppress the airborne noise to acceptable levels. Suitably marinised versions of COTS acoustic enclosures can be readily adapted for auxiliary machinery.

103. **Infrared (IR) Suppression Devices.** Significant improvements in IR-sensing devices make ships increasingly vulnerable to IR detection and IR-seeking missiles. There is a need to develop IR suppression devices to reduce IR signatures of the ships and increase their survivability. These include suppression devices for exhaust gases from Gas Turbines and Diesel Engines and active hull cooling systems for reducing solar heating of the hull. This is a practically unexplored field for the industry and they can work in consultation with the DRDO organisation for an initiation into IR suppression systems.

Hull Systems

104. The futuristic technologies for hull systems must incorporate stealth design, long lasting paints, preservation technologies and improved hull signature management.

Electrical Engineering

105. The indigenous production of the under mentioned Electrical/ Electronic equipment needs examination:-

(a) **Gyros**. Till recently all Western & Russian gyros in use by Indian Navy worked on the principle of rotating mass for angular measurement reference. However, presently the Navy is inducting new generation gyros like Ring Laser Gyros (RLG). These are being procured from abroad and Navy would like to have indigenous manufacturing of such gyros based on latest technology (like RLG or fiber optics) to be available in India for better system availability and product support.

(b) **Logs**. Navy is using Logs to obtain ship's speed based on electromagnetic measurement concept and these Logs are required to give a high accuracy for integration with various weapon control systems and for navigation. Indigenous development of modern logs and their data transmission units is thus required to be undertaken completely in India.

(c) **Echo Sounder.** The Echo Sounders play an important role in depth sounding especially for safe navigation. Navy is looking for modern indigenous Echo Sounders, which can be networked with ship's data bus system for real-time information availability.

(d) **Microprocessor Based ACBs**. Microprocessor based release mechanism for the ACBs have been introduced of late, and there is a need to indigenise these.

(e) **Static Frequency Converters**. The required specific secondary supplies for systems like gyros & radars are derived from the ship's main supplies by using separate rotary frequency converters which have inherent maintenance problems due to moving parts along with EMI/EMC problems. Static frequency converters are better suited for such applications and need to be designed and developed.

(f) **New Generation Zero Maintenance Batteries**. Advanced generation maintenance free batteries with high cranking amps & high deep discharge capability need to be introduced as suitable replacement for lead acid batteries.

(g) **Automated Power Management System (APMS)**. APMS is a new system being planned for induction by Navy. There is however no technology for such systems within the country. In order to exploit the automation in power generation and distribution systems, such systems are going to be installed onboard all future warships and need to be indigenised.

(h) **Modems**. Navy's future requirement would include incorporation of high speed online data & voice encryption/ decryption devices in the existing SATCOM systems in order to obtain message security.

(j) **Electronic Chart Displays**. There is a need to have production of the ECDIS systems in India along with training to enhance navigational safety of ships.

(k) **Command & Control System**. Command, Control, and Communication (C3) system is an information system, which incorporates strategic and tactical systems like a combat direction system, tactical data system, or warning and control system with associated human functions. C3 systems are required to be developed to incorporate following areas in support of commanders engaged in command and control:-

(i) Reconnaissance and Surveillance.

(ii) Environmental Observation and Forecasting.

(iii) Intelligence Analysis.

(iv) Electronic Warfare.

(v) Navigation.

(vi) Integration and Management.

(vii) Strategic and Tactical Weapons Deployment.

(viii) Logistics and Supply.

(l) **Development of Indigenous High Speed Data Link for CAIO.** Requirement exists to identify indigenous sources capable of development of futuristic High Speed Data Links for U/VHF and L Band operations.

(m) **Multifunction Consoles (MFC).** MFCs need to be productionised within the country for better system availability and product support.

(n) **LBTS**. New construction ships have a plethora of sensors and weapons from diverse sources, which are required to be integrated together with Combat Management Systems and Data Networks onboard. The Navy is looking towards vendors capable of development of test beds where ship borne systems could be integrated and de-risked prior attempting integration onboard.

Submarines

106. **Submarine Equipment and Systems**. Submarine equipment and systems are required to conform to stricter and superior material and quality standards. Additionally, future developments in the field of stealth like RCS reduction by RAM/RAP, noise reduction, signature management etc have a large application on the submarines and affect their operations. There is also a need to develop the capability for manufacture of submarine propulsion systems as well as the Fire Control System and its integration with the torpedo tubes.

107. **Anti-Air Weapons**. Submarine Launched Surface-to-Air missiles are being developed by some advanced Navies. This weapon provides a viable defence to a submarine from ASW Helos. Similarly a hoistable, mast-mounted gun for submarines could be a vital part of a submarines weapon fit in the future.

108. **Super-Cavitating Torpedoes**. Developments in the domain high speed Super-cavitating torpedoes are likely to define the realm of underwater warfare in the future. Connected to this will also be the development of countermeasures against the super-cavitating weapons.

CHAPTER 3

CAPABILITY ROADMAP

CAPABILITIES ENVISAGED

1. The existing and emerging security scenario, both global and regional, requires the Armed Forces to maintain a high degree of preparedness across the entire spectrum of conflict. Identifying and developing the capabilities required by the Armed Forces to maintain the decisive edge will be the cornerstone of future defence planning. The tremendous advancement in technology as well as the rapidly evolving scenario in the security environment requires a well thought out capability road map, adequately supported by technology, to achieve optimum combat preparedness. Achieving self-reliance in providing the desired capability requires quality as well as quantity. Capacity-building is therefore an equally big challenge. Achieving both capability and capacity will be possible only with proper planning and ensuring that a clear and coherent way ahead is understood by all stakeholders to achieve optimum utilisation of scarce resources. Synergy between the Ministry of Defence, including the Armed Forces, the DRDO and industry is essential to identify and achieve the desired results. The ability to achieve this through indigenous means should be a national endeavour.

2. The effective harnessing of the scientific and technologically trained pool of manpower, the R&D skills and the technological expertise available with the public and private sector would be the key to achieving self-reliance.

3. This chapter aims to identify the current capabilities of the Armed Forces and highlight both, the augmentation of these and development of new capabilities to achieve the desired level of combat preparedness. Although this document serves to highlight the capability road map for the next 15 years, it must be understood that this is a continuous process and the dynamics of the evolving national and international scenario will require periodic review and constant adaptability for it to become meaningful. Achieving the desired synergy will require a pro-active approach from all agencies, a clear understanding of their constraints and a focussed approach to address these and achieve the desired progress. Definite timelines, committed finances and constructive interaction at every stage would be of essence to achieve the desired results.

4. The current and future desired capability over a 15 year period from 2012 to 2027, as required by the Indian Armed Forces, is enumerated below.

5. **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 one's own. Operational and functional

capabilities needed to achieve IS are highlighted later. Pursuing key IS technologies to develop a '**system-of-systems'** will pave the way for achieving IS.

6. **Network Centric Operations**. Airborne platforms would operate in a net-centric environment in co-operation with space-based systems, surface and underwater platforms and joint assets to provide reliable and realistic intelligence. Communication throughout the battle space will require to be secure, reliable and providing information in real-time. A seamless integration of information from intelligence and surveillance resources will be required to build a Common Operational Picture.

7. **Information Technology**. The salient capabilities which may be included under this category are as follows: -

(a) **Existing Networks**. The existing networks are varied with a wide variety of applications running on them. There is a constant requirement to enhance existing networks to keep with the latest technologies and to support resource intense applications like Video Conferencing. Moreover, most of the network supports only IPv4. There is need to progressively migrate to IPv6 to be in course with the change world over.

(b) **IT Security Products**. Defence Networks, due to the nature of information resident on them, are always prone to attacks. Certain IT Security products like cryptographic tools, firewalls, Anti-virus Solutions, Right Management System etc are already being utilised. However, since the type and methodology of attacks are always changing and rapidly emerging, there is a constant requirement to upgrade existing tools or develop new products to plug vulnerabilities.

(c) **Sensor Networks**. Applications using sensor networks need to be developed to collect, collaborate and disseminate information at a rapid pace. Wireless Sensor Network is an emerging field which has found varied applications, especially for the Military. Applications using Sensor Networks, including underwater sensors need to be explored and developed further.

(d) **Green IT**. Currently, a lot of emphasis is being given for climate change across the globe. IT products which are developed/ bought for the armed forces should be progressively shifted to Green IT products. Also, there is requirement to effectively re-use/dispose the IT waste generated. Support from industry is required to take back IT waste either for refurbishment or for disposal depending upon the status of the equipment.

(e) **Cloud Computing**. This technology is being harnessed by the other Defence Forces as a part of their modernization plans, which will make communication and data transfer seamless, secure and fast. All the applications used by the Defence Forces can be hosted in the Cloud. This will drastically reduce IT costs.

8. **Communication**.

(a) **Strategic**.

(i) **Terrestrial**. An IP/MPLS based network with OFC media can provide unlimited bandwidth to naval users. A large numbers of naval operational applications are envisaged to be ported on the network. In addition, another network based on IP/MPLS technology is envisaged to inter connect all Naval and Coast Guard users. The network would shift, collate and fuse varying data for maritime domain awareness.

(ii) **Satellite**. A satellite-based communication network with high data rate and multiband operation for voice, data and allied applications for providing an extended coverage within Indian Ocean Region.

(iii) **VLF**. Up-gradation of the existing VLF communication setup and construction of another facility at a stand by location for improved communication between shore to submarines.

(b) **Tactical**.

(i) **Radio**. Progressively digitise tactical data-link backbone with capability to transmit/ receive data up to the rate commensurate with that existing in the market.

(ii) **CDMA and WiMax**. CDMA and OFDMA based technologies for application in naval operations. These technologies support services similar to TDMA viz. Voice, Data and video stream with much better QoS and data rates.

(c) Communication capabilities with high band width and high data rate for voice, data, imagery and video transmissions through VHF/UHF/HF and VLF band communication nets and UHF to Ku-band communication via satellites.

(d) High degree of network security with increased levels of encryption / decryption capability. Frequency hopping communication sets with high burst data transmission and secure speech encryption.

9. **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. The capabilities of interest in EW are as follows:-

(a) State-of-the-art EW systems employing cutting edge technologies.

(b) Amalgamation of EW support systems with advanced information and communication technologies.

(c) Miniaturised EW systems as payloads on UAVs, satellite and Aerostats.

(d) EW systems operating in networked environment for enhanced battlefield transparency.

10. **Missiles**.

(a) **Area Missile Defence**. Joint Area Missile Defence is the capability to use AD assets of the three services in conjunction with the surveillance sensors of other agencies to ***detect, track, acquire and destroy incoming theatre ballistic and cruise missiles.*** It encompasses the seamless flow of information on missile launch by specialised surveillance capabilities, through tracking by the weapon sensors to missile negation and destruction.

(b) The Surface-to-Air Strike capabilities comprising both Long Range and Short Range Surface-to-Air Missiles with capability to engage the low flying sea skimming missiles with integrated fire control systems.

(c) Surface-to-Surface strike capabilities comprising Anti-Ship SSMs, and Land Attack Cruise Missiles with fire-and-forget homing heads.

(d) Telemetry systems for monitoring missile flight parameters are critical for operational preparedness and compact, cost-effective, state-of-the-art telemetry systems would go a long way in enhancing the combat efficiency of the Armed Forces.

(e) Development of medium range and long range land attack and anti-ship missiles for aircraft, including light weight, anti-ship missiles.

11. **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. Being able to identify 'Friend from Foe', as also to have a clear picture of all neutrals, is critical for ensuring successful engagements with optimal utilisation of armament, avoiding fratricidal engagements and minimising collateral damage. Modern technologies in surveillance sensors, communication & computing have enabled the task of achieving, sharing and maintaining battle-space awareness. However, combat identification remains a major challenge. Present IFF systems can at best enable a confirmation whether a contact is friendly or not. What is essential to know is, whether it is hostile or neutral as also its type, size and other details, if battle-

space awareness is to be truly achieved. This would require an effort in the direction of identifying various technologies, which need to be developed for Combat Identification. 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.

12. **Precision Force**. This is the *capability to destroy selected targets with precision* using the information available through enhanced battle-space awareness and utilising the best-placed platform for ordnance delivery. It includes effective sensor-to-shooter grid for responsive and timely application of force comprising of surveillance and targeting capabilities for the employment of Precision Guided Munitions (PGMs).

13. **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 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.*** C4I and the associated situation awareness would enable each of the operational capabilities. The challenge is to integrate the technologies into coherent interoperable systems optimised for MOBUA.

14. **Sensors**. Sensor capabilities desired are as under:-

(a) Inter and Intra pulse finger printing capabilities for various sensors with intelligent comparison matrixes coupled with detailed onboard libraries.

(b) IR, electro-optic and laser sensors for aircraft and autonomous vehicles. Requirement exists of higher resolution, greater ranging cameras and laser designators for weapon designations and release.

(c) To embrace software for interpretation and analysis of digital transmissions.

(d) Developmental advancements in airborne avionics and display systems. Improved MFDs/ PNDs for integrated glass cockpits upgradation of aircraft.

(e) Develop new generation, software based and spoof-resistant IFF system with associated transponders.

(f) Development of advanced Self Protection Suit for protection against radar homing/ IR guided missiles. Laser self-protection suit with automatic CMDS / DIRCM.

Aero Space

15. A number of technological advances in satellite system are likely to take place in the near future. The following would be of interest :-

(a) **Use of Ka Band**. To provide larger bandwidths, increase total capacity per satellite, and result in power and cost reduction of ground stations.

(b) **On-Board Processing (OBP) Techniques**. To provide flexible manipulation of base band by allowing connectivity between user of different transponders or in different beams and use of multiple beams in place of single wide beam coverage. Steerable beams to provide communication in less frequented areas. High bandwidth, polar micro communication satellite network, cryptography, data compression and satellite cross links.

(c) **LEO/MEO Satellite System**. To reduce propagation delay associated with geo-stationary satellites, lower orbit satellite system similar to the commercial system like Globe Star and Teledesic.

16. **Combating Terrorism**. This 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). It includes protection of personnel, assault, explosives detection and disposal, investigative sciences and forensics, physical security and protection of infrastructure and surveillance and collection. Successful execution of the wide range of R&D efforts will greatly improve the capability of the soldier.

17. **Logistics Support**. The capabilities which enhance mobility, employability, and sustainability – attributes that are essential for the Armed Forces cannot be achieved without a revolutionary change in the concept of logistics support. A Revolution in Military Logistics (RML) will have to be an integral part of any technological advance used to bolster war-fighting capability and enhancement of readiness for joint operations. There is a need to use technological breakthroughs to transform logistics distribution. Technology has to be leveraged to fusing new organisational structures, concepts, transportation techniques, information systems, and logistic systems. This would fundamentally reshape the way the services are projected into operations and sustained thereafter. Investments in technology are needed which would reduce the bottlenecks that directly impede or delay the capability to support fighting forces. In order to do so, military capability must concurrently maintain the advantage in key areas, develop new areas of logistics support and deny asymmetric advantage to the adversary.

AVIATION

18. **Fighter Aircraft**. Up-gradation of combat aircraft is a continuous process to maintain the fleet's operational relevance. The newer multi-role combat aircraft will replace the present fleet in future. Future combat fleet will therefore be a mix of upgraded aircraft and high technology modern combat aircraft with swing role capability.

19. **Transport Aircraft**. There is a need to enhance heavy lift capability of the Indian Armed Forces. Further, newer generation medium lift aircraft are required to bolster the transport capability and fill the void between LTA and HETAC.

20. **Helicopters**. Build and sustain helicopter fleet to cater for the requirements of strategic and effect-based operations. VTOL hybrid aircraft will add flexibility and range while reducing response time.

21. In consonance with the envisaged growth of the Armed Forces, the capabilities in the field of aviation to support the overall defence strategy are as follows:-

(a) Capability to undertake day and night ops in all-weather conditions.

(b) Modernisation and up-gradation of all fleets to meet the challenges of advancement in technology.

(c) Stand-off weapon capability during day and night.

(d) Force Multipliers like FRA, AWACS, Surface surveillance and Carrier-launched AEW aircraft.

(e) More Attack Helicopters to enhance required capability in this area. Upgrade existing helicopters and induct more helicopters in Medium and High Lift category.

(f) AD assets in terms of radars and SAGW to address multi-level, multi-mode threats and to operate in networked environment.

(g) Multi-spectrum IEW capability, including space-based capability and operational infrastructure for analysis of data and real-time transmission.

(h) Space-based assets for C4ISR, communication of all types, navigation, meteorology and capability to defend own assets.

(j) Stealth Technology.

(k) Independent, jam proof, navigation capability with inbuilt redundancy for the aviation platform.

(l) **Maritime Surveillance** . There would be a need to keep the entire area of interest under constant surveillance. In the maritime theatre, the primary area would be the focal point of the SLOCS, approaches to the Indian Ocean, the entire IOR, Offshore Development Areas (ODAs) and island territories. The increased risk of asymmetric threat and coastal security scenario would necessitate persistent coastal surveillance. The requirements would be met through a surveillance matrix comprising of Long / Medium Range Maritime Reconnaissance (LRMR and MRMR) aircraft, amphibious aircraft and UAVs.

(m) **Fleet Air Defence and Maritime Strike**. With the forth-coming induction of Vikramaditya, the indigenous Aircraft Carrier program and ongoing induction of advanced fighters to operate from these Carriers, fighter aircraft would graduate to discharging multifarious roles. These would include fleet integral air defence, maritime strike, strike against shore targets at extended ranges, escort and buddy refuelling missions.

(n) **Anti Submarine Warfare**. Submarines would remain one of the dominating threats to a ship at sea. Hence, early detection at extended ranges, ability to continually monitor movement and take effective hostile action would be a constant prerequisite for Naval Aviation. This would be achieved through LRMR aircraft at extended ranges, MRMR aircraft at closer ranges / along the coasts and integral helicopters operating from warships.

(p) **Special Operations**. Troop carrying helicopters operating from both ships and ashore would be required to augment aviation assets in order to effectively undertake special operations in difficult terrains, ODAs, island territories, counter asymmetric threat and combat piracy in the IOR.

(q) **Amphibious Aircraft**. Amphibious aircraft would form a key element towards undertaking Coastal / inter-island ferry for personnel and cargo, supply of critical spares to ships and submarines at sea, SAR missions and visual/ radar surveillance of coastal areas and island territories, casualty evacuation at sea, rapid response missions towards induction / withdrawal of special forces and humanitarian assistance.

(r) **Heavy Lift Helicopters**. Heavy lift helicopters would significantly bolster the capability to land troops and equipment both on land and offshore. They would come-in very handy for road building in mountainous terrain.

(s) **Acquisition of Modern Armament**. The envisaged aircraft inductions would be supported by modern integral armament with weapon technologies facilitating faster response and enabling precision strikes to meet emerging threats.

(t) **Simulators**. Development of full motion with six degrees of freedom simulators for all existing and future air platforms. Development of Rear

Cockpit Trainers for mission training of observers. Both simulators should be linkable for full crew training in mission roles.

22. **UAVs**. Towards capitalising on the unique capabilities of UAVs in terms of persistent surveillance, an increased role is envisaged to be played through induction of High / Medium Altitude Long Endurance UAVs and ship based VTOL UAVs. The following capabilities are envisaged in this field:-

(a) Development of land and ship-launched UAVs of Mini and Tactical categories.

(b) Development of unmanned combat vehicles for use from land, ship and submarine.

(c) Development of land and ship-launched/ recovered UAVs and UCAVs with integrated radar / IR/ laser/ video surveillance systems, ESM and ECM and networking capabilities. Data-linking of these UAVs with other units in a net centric data domain for real-time data transfer across multiple pathways.

LAND WARFARE

23. The future land battlefield will extend beyond immediate geographical space and physical domain with the increasing ability of the warring sides to look deep into each other's territory. There shall be near real-time flow of information due to advanced integrated sensors. Precision fires would enhance lethality, cause heavy degradation and provide deep strike capability. The battle would overlap through multi spectral domains, ie, conventional, sub-conventional and non conventional. Technology would be the major force multiplier and would drive cyber, space and information warfare and these would be fought in the back drop of nuclear environment.

24. The capabilities sought to be built up, are enunciated in the succeeding paragraphs:-

(a) Enhanced operational effectiveness of armoured and mechanised infantry fighting platforms, with emphasis on manoeuvrability, lethality, survivability and information dominance.

(b) To develop the capacity to field a wired and net-connected infantry soldier integrated with a battle field management system and equipped with state-of-the-art weapons.

(c) To develop a comprehensive fire power and fire support system based on long range artillery, rockets and missiles with high lethality, precision and mobility.

(d) To achieve a high degree of transparency in the battlefield by means of integrated space-based, air-borne (including UAV mounted), heliborne and surface-based sensors with high resolution imagery and real-time flow of information at all levels.

(e) To enhance night fighting capability by provisioning of state-of-the-art night vision devices.

(f) To move from a net enabled to a net centric Armed Force by integrating space, air and ground platforms. Imperative would also be the ability to control cyber space while ensuring information superiority for own forces.

(g) To achieve enhanced sensor-to-shooter synergy by integration of sensors with fire power resources at the disposal of the force.

(h) To develop an effective air defence capability based on modern radar systems, advanced seekers and guidance based surface-to-air missiles, gun systems and ammunition with advanced hit efficiencies.

(j) To develop a fully integrated combat aviation fleet based on helicopters to form the aerial manoeuvre component of the Force, duly supported by reconnaissance and logistics aerial platforms. The futuristic aerial platforms must comprise advanced avionics, state-of-the-art navigation and weapon systems. The aircraft must have high reliability and survivability in an electronically dense environment.

(k) To enhance mobility of own forces and deny/retard the same to the adversary. The capability of bridging gaps, both wet and dry, development of mine laying and recording technologies and countering adversary's explosive devices would act as force multipliers.

(l) To develop a state-of-the-art Chemical, Biological, Radiological & Nuclear defence and protection capability.

(m) To develop capability to undertake protected operations in built up urban/ semi urban rural areas so as to achieve the military objectives with minimum casualties/collateral damage.

(n) To attain amphibious capabilities of designated forces with fighting platforms and support vehicles which will need to traverse over riverine and such like terrain.

(p) To evolve an agile, responsive, integrated and cost-effective logistics system through use of modern technology and management practices, in synergy with other Services and the national industrial base.

MARITIME

Air Launched ASW Weapons.

25. The following would be required:-

(a) Development of super-cavitating air-launched underwater weapons including high speed torpedoes with extended ranges.

(b) Development of light weight air-launched intelligent mines.

(c) Development of air-launched torpedoes with ranges greater than 15 Km.

(d) Development of intelligent air launched torpedoes with loiter and self detection capabilities.

(e) Weaponisation of UAVs with precision guided ammunition and missiles.

Special Ops and Diving

26. Technology for development of following would be of interest for Special Operations and Diving:-

(a) Special Operations.

(i) Battle Management Systems for integration of the Special Operation elements with other Naval components in a network-centric environment.

(ii) Hands-free secure real-time voice and data transmitting equipment for tactical and area communication.

(iii) Special purpose craft, RHIBs, vehicles and other associated systems for Special Operation teams.

(iv) IR/Thermal and Optical sights for observation and assault, sniper area weapons.

(v) Special Ops equipment and explosives tailor-made to meet symmetric and asymmetric threats.

(vi) Small Arms Simulators and indoor combat work-up stations for conduct of work up and training.

(b) **Diving**

(i) Mine Counter Measures and Explosive Ordnance Disposal related equipment.

(ii) ISR equipment.

(iii) Equipment for conduct of underwater salvage operations.

(iv) Recompression Chambers (RCCs) and associated systems.

(v) Air and Combat Diving equipment.

Coastal Security

27. The following would be of interest in respect of Coastal Security:-

(a) Unmanned Surface Vessels (USVs) for investigation of contacts and patrolling.

(b) Mobile radar and AIS systems to cover gaps along the coast.

(c) Capability to track all vessels at sea in IOR.

(d) Capability to distinguish rogue vessels by Contact Motion Analysis (CMA) and other methods of analysis from the track data.

(e) Modern high definition radars, better optical sights and night vision devices.

28. **Sea Glider**. Underwater surveillance forms an important part of Navy's ability to protect its vessels, personnel and underwater interest from hostile submarines. The Sea Glider can be used to monitor shallow-water environments from fixed positions on the ocean floor or by moving through the water to scan large areas for extended periods of time. These Gliders can achieve 1-3 knot cruise speeds, a 1200-1500 km range, and the ability to remain on-station for up to 6 months in loitering glides at partial buoyancy.

Training

29. Development of state-of-the-art simulators in the field of Navigation, Electronic Warfare, Small Arms training, Flight training, Damage control, Life saving drills and Weapon training.

CHAPTER 4

SUMMATION

CONCLUSION

1. Although the direction and pace of the modernisation plan as well as that of technology cannot be predicted accurately, the foregoing is a fair assessment of the direction most likely to be followed by the modernisation program of the Armed Forces. The exact details could be shared with the industry in greater measure, as and when projects actually come up for implementation. Further, specific programmes or technologies could be discussed by industry in greater detail with the respective Services. This document has been prepared in a Service-neutral format since a large number of the technologies required are common between the three Services, wherein the exact specifications of the equipment for single service requirements in a joint as well as individual scenario may vary even though the technology may be common. Also, many of the capabilities sought have overlapping requirements between the three Services.

2. Self-reliance in meeting the requirement of defence equipment for the Armed Forces is a strategic necessity. Accelerating this pace of indigenisation is now a priority area for the MoD for which the active participation of industry, both the public and private sectors, is very important at every stage of the developmental process. Various mechanisms have been introduced to institutionalise this. Positive interaction between all concerned agencies is vital for progress to be tangible and viable. HQ IDS has initiated measures to develop this relationship through interaction at various levels which have been articulated through various fora, seminars etc. As a part of this initiative, the industry is being regularly invited to articulate its capacity and willingness to undertake projects on the anvil prior to in-house discussions during Services' Capital Acquisition Plan Coordination Committee (SCAPCC) meetings. The effort to give fillip to the process of indigenisation is being pursued in right earnest.

3. This document has attempted to create awareness in industry of the capability and technology requirement of the Armed Forces. It will be regularly updated as and when plans are revised and would therefore attempt to provide the latest inputs on the Technology Perspective and Capability Requirement of the Armed Forces over a 15-year period. It is hoped that this would address the industry's concern about a level playing field. On the part of industry, it is expected that this document will encourage them to put forth firm proposals for participating in the self-reliance process in terms of R&D, production and product support commitments. It is also envisaged that the industry would be proactive and in future suggest options to the Armed Forces vis-à-vis their capabilities and available technologies. Taking a cue from the information disseminated through this document, the industry may undertake capability and capacity building so as to cut down on time period for the acquisition cycle.