TECHNOLOGY NEEDS TO ACHIEVE JOINT WARFIGHTING CAPABILITY

Introduction

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

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

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

4. Increasingly many defence needs can be met by leveraging the commercial technology explosion and utilising commercial products such as computers, software, electronics, and communications. As military capability moves toward information based warfare and as the information age continues to experience a technology explosion in the civilian economy, there will be an abundance of opportunities to leverage commercial technology and products for military use. We should monitor commercial technology and product developments and adopt or leverage them for enhancing military capability. The defence forces, defence planners, scientists, and engineers should be brought together to explore ways to take advantage of the opportunities offered by rapid commercial technology advancements.

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

innovative new concepts for conducting operations, test them through demonstrations and rigorous experimentation and rapidly transition the enabling technologies into revolutionary war-winning capabilities.

Asymmetric Threats

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

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

(a) **Affordability**. Technology projects must focus on increasing the effectiveness of a capability whilst decreasing cost, increasing operational life and incremental improvements through planned upgrades.

(b) **Timeliness/Accelerated Transition**. The emphasis should be to ensure that the time taken for the transition of technology to usable capability is minimised.

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

such technology, but lead to cost effectiveness due to economies of scale.

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

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

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

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

10. The capability objectives required to enable the military to meet the challenges of the future battlefield have been identified and the

likely technologies we would need to develop to achieve such capabilities have also 'been drawn out. These capabilities are: -

(a) **Information Superiority**. Information Superiority (IS) encompasses the capabilities of Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) and Command, Control, Communications and Computers (C^4) 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 C^4 network connecting all own forces to provide a common picture of the battlespace. The capability of information warfare is also needed to affect enemy information systems while protecting own. There is a necessity to define operational and functional capabilities needed to achieve IS. Pursuing key IS technologies to develop a '**system-of-systems**' will pave the way for achieving IS.

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

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

(d) **Combat Identification**. In any battlefield scenario it is imperative that the war fighter is able to have a clear and unambiguous awareness of the identity of all those present in

the area. Modern technologies in surveillance sensors, communication & computing have enabled the task of achieving, sharing and maintaining battlespace awareness. The aim is thus to develop a ***capability with which we can positively identify potential targets as friend, foe or neutral in sufficient time with the highest possible level of confidence and at the requisite range to support weapon release and engagement decisions***.

(e) **Precision Force**. This is the ***capability to destroy selected targets with precision*** using the information available through enhanced battlespace awareness and utilising the best-placed platform for ordnance delivery. It includes the requisite sensor to shooter C^4I capability for the responsive and timely application of such force, which includes the surveillance and targeting capabilities for the employment of Precision Guided Munitions (PGMs).

(f) **Military Operations in Built-Up Areas (MOBUA)**. This is the capability to undertake operations in built-up areas so as to achieve military objectives with minimum casualties and collateral damage. It includes the appropriate precision weapons as also non-lethal weapons, surveillance sensors, navigation means and communication systems that are effective in confined, built-up urban areas. In a broad sense, our combat forces must be able to fight and survive better than their adversaries. The key operational capabilities required are ***firepower, force protection and manoeuvre***. C^4I and the associated situation awareness would enable each of the operational capabilities.

(g) **Combating Terrorism**. This capability includes the capability to oppose terrorism throughout the threat spectrum including anti-terrorism (defensive measures to reduce vulnerability) and counter-terrorism (offensive measures to prevent, deter and respond). This capability includes protection of personnel, assault, explosives detection and disposal, investigative sciences and forensics, physical security and protection of infrastructure, surveillance and collection. Support to land, sea, and air forces would be achieved by the use of improved detection, monitoring and tracking, intelligence and logistic communications, training and planning. ***The principal***

goal of Combating Terrorism is to protect lives and resources and allow forces the freedom of action required to accomplish assigned missions. Combating Terrorism leverages optimal utilisation of limited resources and focuses on technologies that offer significant improvement in force protection capability.

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

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

11. Our acquisition process needs streamlining. We must reduce development time and acquisition costs for fielding critical technology to rapidly meet defence forces needs and remain viable in a constrained resource environment. Increasingly, advanced technology is becoming available on international markets, requiring DoD to accelerate the development process as never before**. Rapidly transitioning technology from S&T to an operational capability is crucial.** To speed up the technology transition process important mechanisms of S&T Development Technology demonstration and experimentation should be established to ensure

the transition of innovative concepts and superior technology to the defence forces with speed and at affordable costs. Technology demonstration should be the key element in the S&T program to determine the military utility of proven technologies, expedite technology transition, provide a sound basis for acquisition decisions, and develop the concept of operations that will optimise effectiveness.

Partnerships

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

(a) Academia and Research Institutes - for their new ideas and knowledge.

(b) DRDO – for their stability, long-term investments in S&T and focus on high-risk, high-payoff research.

(c) Defence PSUs and OFB for technology absorption.

(d) Private and Public Industry-for its innovation and transition of technology.

(e) Other Agencies - for their expanded resource base that leverages resources at the disposable of Department of Defence.

(f) International collaboration for technology development to allow us to address areas where indigenous R&D is weak/deficient.

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

SUMMARY

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

INFORMATION SUPERIORITY

Introduction

1. The Indian Armed forces require which is Information superiority (IS) "**the ability to collect, process and disseminate flow of information while exploiting and/or denying an adversary's ability to do the same**." To achieve IS we must combine the capabilities of Command, Control, Communications and Computers (C^4); Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR); and Information Warfare (IW).

2. An Advanced Battlespace Information System (ABIS) should have the following elements within each of the three broad capability areas: -

(a) **Battlespace Awareness**. This includes information acquisition, precision information direction and consistent battlespace understanding. These capabilities allow the forces to control and shape the pace of the battle by providing Commanders with a broader perspective and better intuitive feel of the battlespace, including environmental conditions and operational situation.

(b) **Effective Employment of Forces**. It encompasses proactive planning and pre-emption, integrated force management and execution of time-critical missions. These capabilities allow the Commanders to plan and execute operations in a manner that achieves an overwhelming effect at precise places and times.

(c) **C^4ISTAR Grid (composed of Sensor Grid, Information Grid, and Engagement Grid)**. It includes universal transaction services, distributed environment support and high assurance of services. These capabilities allow the Commanders to rapidly adapt to changing situation and environmental conditions and to attach high-priority to targets throughout the Battlespace. Information superiority empowers lower echelon force elements by widely distributing the Commander's intent and the information needed for timely and effective execution. Since these capabilities inevitably degrade in the course of battle, a key objective of IS is to enable Commanders to plan for this eventuality, to identify and

protect essential capabilities, and to reconfigure information flows and supporting C^2 structures to meet changing needs. This high degree of flexibility can be achieved by a network-centric approach to the integration of current and future sensor, information, and engagement grids into a single C^4ISTAR grid.

Battlespace Awareness

3. It includes the operational capability to acquire and assimilate information about the location and movement of friendly and adversary forces and about the geo-spatial situation (e.g., terrain, weather, space, bathymetric conditions) in which they are deployed. To provide a common picture and understanding of the situation, which will enhance and the ability of the Commander to identify and localise features of the battlespace in the face of degraded environmental conditions and hostile countermeasures.

4. The specific operational capabilities necessary to achieve battlespace awareness are as follows: -

(a) **Information Acquisition**. The provision of sufficient, timely, high-quality surveillance, reporting, target acquisition and assessment information on enemy, friendly, and own units, events, activities, status, capabilities, plans, and intentions to ensure that Commanders have dominant battlespace knowledge.

(b) **Precision Information Direction**. The capability to dynamically direct and integrate both tactical and supporting C^4 and ISTAR resources for targeting, engagement, Battle Damage Assessment (BDA) and combat assessment to maintain the ability of the Commanders to exploit and shape the battlespace. This also includes the integration and synchronisation of information into up-to-date mission products needed by the Commander and staff for effective decision-making.

(c) **Consistent Battlespace Understanding**. The capability to elevate the level and speed of the combatants' cognitive understanding of enemy, friendly, and geo-spatial situations and to maintain consistency in that view across tactical and supporting forces.

The C4ISTAR Grid

5. The C4ISTAR grid will support complete connectivity with flexible, rapidly configurable network services, facilitate universal user access to information, and assurance of services in stressed environments. These services will also provide flexible command structures and support for time-critical, short-duration mission tasks such as “sensor-to-shooter" integration and support. The services of the C4ISTAR grid should be to an extent conceptually separate from command structures, disseminating battlespace awareness to users when they need it and in the form that they need, to facilitate collaborative planning and execution of operations. Achieving connectivity and flexibility across heterogeneous systems will also allow the creation of "virtual staffs".

6. The critical operational capabilities of the C4ISTAR grid are: -

(a) **Universal Transaction Services**. The capability to provide combatants and their systems the ability to exchange and understand information, unimpeded by differences in connectivity on a "just-in-time" basis, regardless of location.

(b) **Distributed Environment Support**. The mechanisms and services required to allow the combatants to craft their C4ISTAR information environments from the full set of assets connected through the C4ISTAR grid, including the ability to establish distributed virtual staffs and task teams. All this also requires considerable organisational decentralisation.

(c) **High Assurance of Services**. High-quality services that combatants must have, when needed, to meet dynamically changing demands and defend against physical and information warfare threats. This includes adaptive network management that anticipates changing requirements, and the defensive IW operational capabilities of information security, operations security, information integrity, attack detection and restoration. Information security encompasses confidentiality, integrity, authentication, non-repudiation, and to some extent, the availability. Operations security ensures that own critical information and activities cannot be easily intercepted or observed by adversary intelligence systems. Information

integrity ensures that the information to support Battlespace awareness is unimpaired.

Functional Capability.

7. The C^4ISR grid continues to evolve into a "**system-of-systems**". A focus on total life cycle systems engineering will be needed to achieve end-to-end performance. Some of the important functional capabilities needed to achieve information superiority are given below:-

(a) Collaborative situation assessment and BDA.

(b) Collection and distribution of weather and environmental conditions.

(c) Repair and consumables management.

(d) Theatre intelligence processing and broadcast.

(e) C^4ISTAR system management.

(f) Seamless connectivity.

(g) Space assets.

(h) Knowledge-based access, retrieval, and integration of information.

(j) Information consistency, integrity, protection and authentication.

(k) Access controls / security services.

(l) Network management and control.

(m) Intrusion detection / threat warning.

(n) Large database engineering, manipulation, search and retrieval.

Conclusion.

8. Achieving IS and seamlessly integrating IS into combat operations will require both advances in technology and development of new operational concepts to exploit them. Information Superiority has significant potential to transform our approach to assigned mission and achieve worthwhile improvement in effectiveness and efficiency. However, the same will not be realised by simply creating information infrastructure. In fact we have to take decisive steps to develop IS based mission capability packages, absences of which will lead to confusion and disharmony along with degraded performance. Two key pre-requisites are, development of new and innovative IS concepts and strategies to meet mission challenges and the ability to transform these concepts and strategies into operational capabilities.

ELECTRONIC WARFARE

Introduction

1. Control, management, exploitation and manipulation of the EM spectrum both for own as well as enemy use have proliferated in this information Age. Powers of IT, processing capability, digital equipment has, on the one hand delivered the benefit of transparency. On the other hand it has resulted in rendering such systems vulnerable to diverse and radically new and novel counter-attacks. With majority of modern combat systems relying on electronics and the RF spectrum, there has been a need-felt to re-define the traditional warfare discipline of EW.

2. Electronic Warfare, includes the following: -

(a) Capabilities for deceiving, disrupting or destroying enemy surveillance, C^2 and weapon systems and / or sensors, viz., early warning, acquisition and targeting functions associated with enemy's integrated / area defence network.

(b) Recognising attempts by hostile systems to track or engage own forces, and automatically initiating countermeasures or defensive response.

(c) Protecting own systems through redundancy and hardening.

3. The evolution of digital RF memories and wide use of digital signal processing will allow more flexible and tailored ECM response. Improved understanding of threat systems and increased use of computer-based modelling and simulation will enhance EW capabilities. Directed Energy Weapons (DEW), High Power Microwaves (HPM) and Electromagnetic Pulses (EMP) may be used to disable or physically disrupt electronic systems. ECCM measures will improve systems robustness against attacks by modelling and simulation of RF effects on electronic equipment and by developing appropriate shielding techniques. This will reduce platform vulnerability to radar detection and RF guided missile attack by

modelling and measurement of the RCS and by supporting RF signature reduction research. Integration of the total EW function, including the Electro-Optical (EO)/Infrared (IR) components with weapon systems and other sensors across multiple platforms will lead to effective, rapid and informed responses to threats.

4. **Electronic Countermeasures**. The capabilities in this area would include: -

(a) Development of wide area distributed database, advanced antennae, precision targeting in the low-GHz range.

(b) Signal recognition, demodulation and Electronic Countermeasure waveform generation against commercial grade, high capacity cellular and satellite transceivers.

(c) Development of advanced countermeasures against new multi-mode guided missile seekers and imaging radars during terminal phases.

(d) New techniques to counter surveillance and targeting radars, denying acquisition and suppressing subsequent missile launch and active and passive homing threats.

5. **Electronic Support Measures**. This field perhaps is of the most value for combat operations with its added dimension of Electronic and Communication Intelligence (Elint & Comint respectively). Therefore, the mission capability profile of this realm of EW has to be much more comprehensive then the other two, especially in view of the fact that ECM and ECCM measures rely on very precise, accurate and high-integrity information provided by ESM systems. In addition, the tactical dimension of Sigint collection and analysis has become an important dimension of modern day Electronic Warfare, and in turn, Electronic Support functions. The tactical underpinning of these systems, therefore, cannot but be overemphasised. It therefore devolves that :-

(a) Next generation ESM processors must offer improved emitter identification, de-interleaving techniques, DF and geo-location algorithms, multi-path suppression techniques and increased capability in the SHF region.

(b) Development of correlation and templating, automated tracking, cross-queuing and situation display tools.

(c) Integration of ceramic phase shifters in phased array antennae, application specific ICs for Fast Fourier Transform processing and tools and techniques for tasking and reporting from multi-intelligence platforms.

6. **Electronic Counter Countermeasures**. These measures are specific to each platform, sensor, and equipment and even component. Therefore, it would call for: -

(a) Tailoring of generic protection technology and techniques to satisfy ECCM requirements of specific system.

(b) Ameliorating the effects of hostile jamming, deception, targeting or DEW attacks.

Technology Objectives

7. Based on current technology trends world-wide as well as within the country, the Mission Capability requires to be translated into a comprehensive R&D priority to achieve the requisite technology objectives. These would broadly dictate the short, medium and long-term basis for the technology road-map to be followed to address, identify and plug the gap in our current and future capabilities in the field of Electronic Warfare. The objectives have been formulated on a generic basis so as to afford the R&D agencies and laboratories sufficient latitude for researching key thrust areas. Apart from the above, the user peculiarities too would shape adoption of technologies in specific sensor / equipment. Therefore, it is intended to cover a wide range of activities keeping in mind the current and evolving threat scenarios that would impinge on our combat capability.

8. **Electronic Countermeasures**. The technology objectives in this field would include: -

(a) Development of advanced signal ID and detection algorithms for **real-time** RF threat detection, ID and Geo-location.

(b) Provision of distributed/parallel COTS multiprocessors for providing missile approach warning.

(c) Production of high-sensitivity, multi-band detectors that would enable modular, programmable EW receivers.

(d) For Elint and data fusion, developing digital and channelised receivers with directional apertures, low false alarm, high sensitivity missile warning systems with real-time techniques for correlation/fusion of all data.

(e) Development of a comprehensive suite of expendable/ decoy-based countermeasures, incorporating the entire spectrum of technologies including DRFM/FPM/IRCM/laser-based EOCM etc.

(f) Development of countermeasures against surveillance, acquisition and C^2 laser-based CM and other surgical RF countermeasures using compact lasers, coherent, Doppler, mono-pulse and false target countermeasure techniques.

(g) Develop techniques to utilise negative SNR, parallel signal channel tracking and algorithm techniques and provision of near real-time code-breaking techniques to handle complex C^2 signals.

(h) For successful non-fratricidal C^2 jamming, development of high-efficiency linear, solid-state amplifiers, efficient HF/V/UHF antenna designs (e.g.. high temperature, super-conductivity arrays).

(j) For delivering lethal SEAD, research in frequency/bandwidth aperture function control techniques (ECM Vs ESM) and developing large extent phased arrays.

9. **Electronic Support Measures**. In order to enable recognition and tracking of signals, high-fidelity identification is mandated. Additionally, there is an overarching need to develop systems and technologies to address the tactical dimension of ESM systems. These would engender development of systems using following: -

(a) < 1° beam-forming systems.

(b) Rapid, high fidelity Analogue to Digital (AtoD) conversion hardware/processing.

(c) Software re-configurable/open architecture to enhance interoperability between systems.

(d) Development of expert systems and algorithms to enable all-source data integration/fusion.

(e) Wide-band data-linking and advanced UAV payloads for hostile battle-space signal interception and/or collection.

(f) Technologies and operational capabilities for hand-held and/or man portable DF systems.

(g) Develop adaptive, miniaturised, lightweight Elint and Comint systems that could be utilised for ISTAR purposes, without compromising on capability. Technologies in this realm would include among others, interferometry, nano-technology etc.

(h) Fast deployable, light, vehicle-based system with a low profile for siting in company posts with sufficient mobility and minimum power requirement.

(j) Compact and small profile ESM system with specialised geometry for antenna mounting, drawing power from the helicopter and a low-speed data link over VHF for integration with ground elements for detailed offline analysis.

(k) Compact systems that can operate from bunkers in Master-Slave configuration enabling unattended operation of Slave.

10. **Electronic Counter Countermeasures**. Developments in this field relate to the following: -

(a) Multi-function, multi-spectral warners.

(b) Uncooled law false alarm-rate detectors.

(c) Low cost and temperature stable IR/UV filters.

(d) High-speed, wide-band receivers based on GaAs (Gallium Arsenide) technologies.

(e) High power ultra wide-band (UWB) jamming modulators and transmitters.

(f) Modelling and simulation tools to study and measures the effects of DEW for developing suitable shielding.

(g) Modelling and measuring RCS and RF signatures to reduce platform vulnerability.

Conclusion

11. The desire and ability to control the RF spectrum during a conflict is placing large demands on the designer of systems as well as the developers of countermeasure systems.

12. Through a combination of development of Mission Capability Statements based on the functional capabilities of each element of EW operational capability elements viz., ECM, ESM and ECCM, it has been endeavoured to identify technology objectives required to fulfil the inadequacies existing currently as also addressing the developments likely to be undertaken in the future. Therefore, the way ahead for our R&D tasking requirements would revolve around the following strategic objectives.

13. Development of EW R&D priorities to counter emerging threats: -

(a) Forecasting new conventional and systematic RF threats, based on intelligence reports, advances in radar, telecom and relevant enabling technologies, analyses and experimentation.

(b) Formulating new R&D priorities and approaches for the develop

(c) Apply increasingly capable modelling and simulation tools to assist in threat engagement assessments.

14. Development of technologies and techniques to improve EW system capabilities: -

(a) Developing new technologies to respond to broad multi-dimensional threat emitter parameter sets with precision and resolution.

(b) Exploiting flexibility of digital signal and data processing techniques for new, programmable, adaptive EW systems to enable 'surgical' responses to, and suppression of, targeted opponent systems, while minimising the effects on non-target emitters.

(c) Developing techniques for specific emitter identification and engagement for shielding against RF weapons and to optimise effectiveness of own defensive systems.

15. Development of systems for automated situation interrogation, assessment and response for effective operations in future EW environment :-

(a) Developing EW systems that can autonomously interrogate the RF environment, adjust to changing engagement priorities, undertake threat assessment and apply adaptive response mechanism.

(b) This is achieved by integrated a priori information with data from multiple, distributed and networked sensors, using processes derived from Artificial Intelligence, neural networks and automatic feedback control, by deploying specialised autonomous vehicles and by optimising operator monitoring and control procedures.

16. Enhancing situational awareness capability to the level of identifying individual emitters, employing countermeasures and at the same time ensuring uninterrupted operation of own sensors and equipment is a formidable challenge. The necessity of addressing this challenge through operator-customisable technology solutions that can be manipulated and used in an extremely fluid and dynamic combat environment of tomorrow's battlefield would decide the ultimate outcome. It, therefore, devolves on all of us to work together

towards achieving the desired level of self-sufficiency in indigenous technologies to address the various threats highlighted in the preceding sections.

AREA MISSILE DEFENCE

Introduction

1. The vision for a future Area Missile Defence architecture represents theatre-wide set of surveillance systems, and a highly responsive C^4ISTAR network to integrate the surveillance and weapon capabilities. The netted set of surveillance systems includes airborne, ship-borne, and land-based radars in conjunction with space surveillance systems to detect launches of theatre ballistic and cruise missiles and track them until they are successfully intercepted.

2. **Area Missile Defence Mission Statement**. The mission of Area Missile Defence is as follows: -

(a) To demonstrate our resolve to deter aggression through the establishment of an Area Missile Defence capability.

(b) To protect deployed forces, critical assets, and areas of vital interest from attack by theatre missiles (TM).

(c) To protect population centres, fixed civilian and military assets, and mobile military units.

(d) To detect and target TM systems; to detect, warn and report a TM launch; and to coordinate a multifaceted response to a TM attack, integrating that response with other combat operations.

(e) To reduce the probability of and/or minimise the effects of damage caused by a TM attack.

Operational Capability Elements

3. This section focuses on the active defence pillar and those aspects of the C^4ISTAR element that are unique to the Area Missile Defence mission. The four operational capability elements, of Area Missile Defence are as follows: -

(a) Offensive operations.

(b) Active defence.

(c) Passive defence.

(d) Command, Control, Communications, Intelligence, Surveillance, Targeting and Reconnaissance (C^4ISTAR).

4. **C^4ISTAR**. In addition to the functional capabilities required for passive defence, the functional capability of Boost Phase Intercept-Laser is essential in the target intercept area.

Functional Capabilities

5. The functional capabilities are grouped into those activities, which support the three functional areas of **Acquisition Sensor**, **Target Intercept** and **C^4ISTAR**.

6. **Acquisition Sensor Area**. In the acquisition sensor area, the four functional capabilities are **Detection**, **Tracking**, **Discrimination/Identification**, and **Communications**. Rapidly detecting theatre missile launches and establishing current and accurate tracks for those missiles are essential for initiating the active defence against the attacking missiles. In addition, the detection, tracking, and communications functional capabilities strongly support passive defence by providing attack warning and impact point predictions to threatened areas. These three functional capabilities also strongly support attack operations by accurately identifying missile launch locations so that the launchers can be promptly attacked. The functional capability to distinguish a ballistic missile warhead from accompanying missile components or fragments and decoys is essential for initiating the active defence for attacking the right target. In addition, the attack characterisation information about the missile type and potentially the type of warhead from discrimination sensors moderately supports both the attack operations and passive defence operational capabilities.

7. **Target Intercept**. In the target intercept area, the first three functional capabilities i.e., **Lethality, Envelope** and **Terminal Phase** specifically refer to capabilities of interceptor missiles (often called **kinetic energy** interceptors in contrast to **directed-energy** or **laser intercept**). The capabilities of the sensors onboard the interceptor missile or laser weapon platform should be able to: -

(a) Acquire the right target based on hands-off information passed from acquisition sensors through the C^3I system.

(b) Discriminate between the target warhead and missile fragments or decoys.

(c) Maintain tracking of the target until the intercept is completed.

8. **Communication**. The communications functional capability links the interceptor missile or laser platforms to the acquisition sensor functional capabilities. The final target intercept functional capability is boost-phase intercept with laser weapons, either airborne or space based. The laser weapon platforms because of the onboard acquisition sensor and communications capabilities envisioned for them would also support the C^4ISTAR and attack operations operational capabilities by forwarding missile launch and tracking data that have been acquired.

9. **C^4ISTAR**. The C^4ISTAR area includes functional capabilities for high capacity datalinks to rapidly pass acquisition sensor data; and for specialised waveforms to forward missile tracks among elements of the Area Missile Defence forces. C^4ISTAR also includes the functional capabilities of very high throughput data processing to capture, analyse and disseminate the sensor data with minimum delays; and data fusion capability to synergistically combine tracking and discrimination data from multiple sensors of different types.

(a) Target manoeuvring is another key limitation that imposes additional lateral acceleration and diverts propulsion requirement on missile interceptor technology. Current TBMs may manoeuvre unpredictably during re-entry because of missile dynamics or re-entry vehicle asymmetries and advanced re-entry vehicle could potentially take evasive manoeuvres, thus reducing the probability of successful intercept. Therefore, technologies that enhance interceptor manoeuvrability and improve interceptor probability of kill would allow a reduction in interceptor inventory and could significantly reduce Area Missile Defence costs.

(b) Two other significant barriers for Area Missile Defence are sensor/data fusion and target signature data. Sensor fusion is a challenging technical barrier for Area Missile Defence because fusion must take place in near real-time in order to be useful for

guiding intercepts. Sensor data fusion is a technique in which multiple sensors provide individual data sets on targets and backgrounds, which are then processed into a single merged set of data. The fused data present a much more accurate picture of the battlespace to the field Commanders than the sum of the individual data sets. The data fusion process occurs in one of the following three ways: -

(i) The fusion of data from several sensors on the same platform e.g., thermal imaging sensor and laser radar onboard an interceptor or a space surveillance satellite.

(ii) The transfer or handover of data from one sensor platform to another e.g., target object map data handover from one surveillance sensor to an interceptor.

(iii) The merging of track files recorded and processed from two or more geographically separated sensors e.g., ground radar and space surveillance sensor data track files.

(c) Availability of accurate target signature data is also a key barrier because successful TMD detections and intercepts, particularly hit-to-kill intercepts, require accurate and reliable target signatures. Threat signatures drive the designs of the detection and tracking radars and optical sensors and seeker hardware selections. They also establish requirements for the supporting detection, discrimination, aim-point selection and kill assessment algorithms. The primary limitation on obtaining accurate signature is generally the lack of access to the actual missile threat operating in their deployed environment. To compensate for this our R&D organisations will have to plan for a facility for signature flight and phenomenology programme where both simulated threats and acquired threats are flown and measured.

(d) Some potential barriers to operating in disturbed environments that are not unique to the Area Missile Defence mission for achieving mission goals in the presence of jamming, weather, solar and nuclear disturbances must also be borne in mind when working on key technologies associated with Area Missile Defence.

Way Ahead

10. The lower tier systems with moderate velocity missiles have only limited capability against longer-range theatre ballistic missile (TBM) threats with higher re-entry velocities, particularly if the attacking missiles are fitted with WMD warheads. Chemical or biological warheads intercepted at low altitude could still disperse hazardous materials over defended areas, particularly if the warheads contain sub-munitions. Therefore, upper tier Area Missile Defence systems with high-performance interceptor missiles capable of defending larger areas and intercepting targets, including WMD warheads at higher altitudes need to be developed for both land and sea basing. In addition, there is an urgent need to develop a highly mobile system to be deployed with manoeuvring forces to provide coverage against short-range TBMs, cruise missiles and other aerodynamic threats.

11. The characteristics of the land attack cruise missile threat presents special challenges for the Area Missile Defence mission. Cruise missiles can fly at low altitude to avoid detection, can manoeuvre unpredictably to evade intercept and can be launched from aircraft and mobile surface carriers, thus reducing the likelihood of pre-launch suppression. Furthermore, advanced cruise missiles design can have very low radar and infrared signatures that make the missiles very difficult to detect against low-altitude background clutter. Therefore, the R&D programme for Air Defence must cater for the surveillance systems and interceptor missiles possessing capabilities to detect, track and intercept cruise missiles.

12. In order to achieve speedy success in the field of Area Missile Defence, our R&D agencies must take immediate initiative to attain the perceived goals by developing the required key technologies. The various functional capabilities vis-à-vis operational capability elements along with the key technologies required for Area Missile Defence are as follows: -

(a) **Operational Capability Element–C^4ISTAR**. Its required to coordinate exchange of information among sensors, radars, launch platforms, interceptors and command centres and for all this, the prerequisite are as follows: -

(i) Acquisition sensor communications.

(ii) Target intercept communications.

(iii) C^4ISTAR viz., Datalinks, Waveform, Data Fusion and Data Processing.

(b) **Active Defence Capability** .

(i) The functional capabilities required are acquiring and tracking the target and handover/communication data to command centres; interceptor launch bases and laser platforms are the Acquisition sensors for Detection, Tracking, Discrimination and Communication.

(ii) The key technologies required for advanced lightweight signal processor are as follows: -

(aa) High power T/R modules.

(ab) Large – format, high – uniformity, single band and multi band LWIR focal plane arrays.

(ac) Lightweight antennae.

(ad) Cryogenic power.

(ae) Eyesafe laser radar.

(ii) In order to neutralise the threat, the key technologies required are as follows: -

(aa) Solid propellant divert.

(ab) Onboard sensor signal processor and algorithms.

(ac) Lightweight laser radar.

(ad) High-sensitivity, multispectral IR sensor.

(ae) Fast framing seeker.

(af) Sensor windows (IR and RF) for hypersonic atmospheric interceptors.

(ag) Sensor data fusion.

(ah) Target discrimination algorithms.

(aj) Lightweight chemical laser.

(ak) Adaptive optics and beam control.

(al) Atmospheric compensation and tracking.

(am) High-stiffness, lightweight structures.

(iii) The key technologies needed to receive, process and transfer data are as follows: -

(aa) Omni-EHF antenna.

(ab) Advanced fusion algorithm.

(c) **Passive Defence**. For early, long-range, accurate threat acquisition, tracking, and data distribution, the key technologies required are as follows: -

(i) Laser communications.

(ii) Satellite electric propulsion.

(iii) High-efficiency photovoltaic.

(iv) Active pixel visible sensor.

(v) LWIR GaAs sensor.

(d) **Offensive Operation**. The key technologies required to coordinate cooperative acquisition, tracking, decision-making and kill assessment are as follows: -

(i) High-speed datalinks.

(ii) Target discrimination algorithms.

(iii) CDMA spread-spectrum communications modems.

Technological Advancements

13. Technology development and demonstration efforts that directly support Area Missile Defence must focus on the following areas: -

(a) Enhancement of ground and airborne radar and space, airborne optical sensor capabilities to improve missile launch detection, tracking and discrimination.

(b) The interceptor missile performance must include onboard discrimination and divert manoeuvring capabilities for both exo/endo-atmospheric interceptors.

(c) The feasibility of boost-phase intercept with airborne and space-based laser technologies.

(d) C^4ISTAR systems capable of rapid processing and transfer of massive amount of sensor and tracking data required to support defensive intercepts.

14. Some of the key technologies needed to breach the limitations for achieving the Area Missile Defence functional capabilities and to enable the AMD operational capability elements that are being addressed by the technology development and demonstration efforts in the western countries is listed below:-

(a) Discriminating interceptor technology programme.

(b) Advanced X-band module.

(c) Advanced space surveillance.

(d) Atmospheric interceptor technology.

(e) Airborne lasers for Area Missile Defence.

(f) Microwave SiC high-power amplifiers.

(g) Advanced focal plane array technology.

(h) Optical processing and memory.

(j) Photonics for control and processing of RF signals.

(k) High-density, radiation-resistant microelectronics.

(l) Space radiation mitigation for satellite operations.

(m) Satellite infrared surveillance systems.

(n) Multi-mission space-based laser.

15. **Conclusion**. The Area Missile Defence threat is evolving rapidly. Such threats include not only Theatre Ballistic Missiles, but also Cruise missiles, UCAVs and eventually Stealth attack aircraft. There is an urgent need to enlarge the scope of the R&D programme for Air Defence to include advanced space surveillance, space-based infrared systems (SBIRS), boost phase intercept lasers, interceptor discrimination, advanced endo-atmospheric interceptor and airborne laser etc.

COMBAT IDENTIFICATION

Introduction

1. Complexities of today's technological environment has created a crisis of identity for all living and non-living beings. Be it a individual who is to be identified by his name, number, father's name, postal address, house number, bank account number, PAN number, voter's list number, Driving License number etc, or be it a commodity like Refrigerator, Television or Car identified by model, colour, weight, make & type, engine number, chassis number, batch number, lot number, year of the manufacture etc. All these identification labels are required for same component or individual by different persons / organisations for different purposes. Hence there is a crisis of identity for all living / non-living beings. Depending upon the type of requirement and urgency, the identification solutions are sought using technology. Intensive research work is presently under progress for various identification technologies.

2. To achieve this objective we need positive, timely and reliable identification of friends, foes and neutrals with accurate characterisation, in our all mission areas i.e. air-to-air, air-to-surface / sub surface and surface-to-surface/sub-surface/air. This will facilitate a Commander to use his forces effectively.

Objectives of CID

3. A combat identification system should be able to achieve following objectives in a combat zone: -

(a) Should be positive, timely and give reliable identification of friends, foes and neutrals.

(b) To optimise mission effectiveness by correct employment of weapon and forces.

(c) To minimise own casualties.

(d) To effectively manage and control the operational area.

(e) Should be interoperable between three Services.

Operational Capabilities

4. The vision is to develop a capability that ensures that all combatant platforms will have the required identification information in a timely fashion that is commensurate with the range and lethality of the weapon platform. The approach towards realising this vision is through an integrated CID architecture that combines non-cooperative and cooperative identification sensors and systems with Command Control and Communication (C^3) capabilities. Such architecture supports the development of situational awareness, the overall general knowledge of the tactical area and combat operations environment, including the location of friendly, neutral and enemy force as well as the plan of action for battle. The required operational capability will then be achieved by combining onboard data from multiple sensors and system with indirectly supplied onboard information.

5. Due to the fundamental difference of their operating environments, the operational capability elements can be aggregated into three categories – air, ground and maritime platforms. Air platforms are more dispersed, move at much higher speeds, and are engaged at relatively long ranges with imaging or non-imaging sensors. Ground platforms are closely spaced, move slowly and are engaged at close ranges with imaging sensors. Maritime platforms are relatively slow compared to air platform, can be either closely spaced or more dispersed and are engaged at longer ranges than ground platforms.

6. The degree of success of combat identification programme will depend upon capability and efficacy of Automatic Target Recognition technology, sensor performance, target complexity and density, target environment and required response time. A careful analysis of exact operational requirement maturity levels of various technologies and availability of commercial off-the-shelf (COTS) multi-chip modules will dictate the objective of achieving the desired capabilities in the given time frame. This needs to be carefully evaluated. Functional capabilities of all combat identification system must work synergistically to provide robust high-confidence-level CID capabilities. Secured integration of IFF Devices amongst the three services is recommended. This need to be seamless and synergised

at Tri Service battle concept level. It also includes Sensor recognition and Non Cooperative Target Recognitions (NCTR) development. There is a need to integrate IFF with radar and weapon systems of each service. It assumes greater importance with stand off weapons.

Functional Capabilities

7. The combat identification system should have following functional capabilities: -

(a) The system should be able to differentiate between a target and a decoy.

(b) Having identified that it is a target and not a decoy, the system should identify the class of target i.e. whether missile or aircraft or should distinguish between tank or vehicle, ship or submarine etc.

(c) Having identified the target by class, the system should identify target parameters such as target platform type.

(d) Such an identification should be done at standoff range i.e. the range at which weapon platform remains outside the reach of target weapon system.

(e) The system should rapidly distinguish among friendly, neutral and adversary forces to support employment of weapon with minimum response time.

8. By developing above capabilities, military objectives can be attained and also causalities, minimised. This will reduce our own attrition rate and thus CID will become a force multiplier.

9. Several technologies required for information superiority, precision force and missile defence are also required for combat identification. Some of these technologies are given below: -

(a) Radar Sensors.

(b) Electro Optical Sensors.

(c) Acoustic Sensors.

(d) Automatic Target Recognition.

(e) Integrated Platform Electronics.

(f) RF Components.

(g) Microelectronics.

(h) Electronics Materials.

(j) Electronics Integration Technology.

(k) Terrestrial Environments.

(l) Ocean Environment.

(m) Lower Atmosphere Environment.

(n) Space/Upper Atmosphere Environment.

Key Technologies

10. Following key technologies have been identified for development of Combat Identification capabilities: -

(a) Fusion Technology.

(b) Database Management.

(c) Moving Surface Target Imaging Radar.

(d) Radar Image Processing Technology.

(e) IR Focal Plane Array Technology.

(f) Advance IR Sensor Technology.

(g) Electronic Support Measures.

(h) Secure Data Links Technology.

(j) Automatic Target Recognition Technology.

(k) Simulation Modelling and Target Configuration Technology.

Conclusion

11. Various key technologies for combat identification have been identified. We are required to establish the maturity level of technologies in these areas. In each of these critical technologies we are required to asses the technology maturity level and wherever the maturity level is below 0.5 we should identify most suitable R&D

agency in the country as a nodal agency for developing requisite technology. Subsequently, the agency must be given a time-bound schedule to present Concept Technology Demonstration and also the Advance Technology Demonstration in the assigned technology. The request for information should be communicated to the national scientific and engineering community to proceed further. Various military users of this technology must converge their requirements on the exploitation of their mission objective.

PRECISION FORCE

Introduction

1. The battlefield environment has undergone rapid changes due to enhanced pace of activity, increased lethality of weapons and military technologies. This was amply demonstrated in the recent Iraq war. One must keep in stride with the fast changing military technologies to win the war of tomorrow.

2. Indian Armed Forces are in need of a “Precision Force”. This calls for a systems approach that enables our forces to locate and identify the target, provide responsive command and control, generate the desired effect through precision targeting and retain the flexibility to reengage with precision when required. Precision Force includes surveillance, targeting capability and precision-guided munitions for increased weapon range accuracy and effectiveness. It also requires advances in sensors C^4ISTAR capability.

Operational Capability

3. The Precision Force is achievable only with heavy reliance on many technologies being developed to support other warfighting capabilities and by optimally utilising these capabilities, the Commander will be able to attack and neutralise enemy forces. The operational capability elements associated with Precision Force are: -

(a) Mission planning.

(b) Weapon employment.

(c) Combat assessment

(d) C^4ISTAR

Mission Planning

4. The Mission Planning operational capability element is dependent on battlespace management, target prioritisation, long-range sensors and timely intelligence dissemination to the users. The mission planning process begins once the target has been identified

(by air or ground targeting system) and a strike is ordered. As part of this process, target priorities are set and strike assets are selected and thereafter it goes to weapon employment phase.

Weapon Employment

5. Once the weapon platform is selected and target acquisition is made by the strike element, the weapon is launched. With the real-time update to Commanders of the battlefield scenario, the launched weapon should be capable of retargeting, should the initial target be destroyed by weapon platform, or should another target become a more serious or time critical threat.

6. Inadequacies in the area of weapon employment are: -

(a) Inability to satisfy the simultaneous need for sensor information.

(b) Limited ability of sensor to acquire and track multiple targets.

(c) Lack of an all weather day/night precision weapon capability.

(d) Insufficient weapon ranges.

(e) Lack of hypersonic weapons.

(f) Inadequate Battle Damage Assessment.

(g) Availability of non-lethal weapons.

Combat Assessment

7. Combat assessment is vital for gauging attack effectiveness, for planning follow-up strike and assessing the enemy's ability to continue. Combat assessment is dependant on all weather sensors, responsive targeting and planning product, and counter camouflage, concealment and deception.

8. **C^4ISTAR**. It is essential to collect, collate and disseminate all data and information of military interest with a view to direct, support and monitor forces and strategic weapons. Without the ability to communicate in real-time, between the battlefield and fire support element (air, land, sea or ground based), the destruction of time

critical targets becomes difficult. It is highly dependant on effective correlation and fusion of data from different sensors. Shortcomings in C^4ISTAR are many.

Conclusion

9. Developing a Precision Force capability is a mission requirement across the entire area of combat operation on land, sea and air and necessitates enhanced "**system of system**" capabilities in mission planning, C^4ISTAR, weapon employment and combat assessment. The above analysis makes a general assessment of the functional capabilities of Precision Force highlighting the key technologies that need to be addressed.

MILITARY OPERATIONS IN BUILT-UP AREA (MOBUA)

Introduction

1. Military Operations in Built-Up Area (**MOBUA**) is the capability to operate and conduct operations in built-up areas and to achieve military objectives with minimum casualties and collateral damage. **MOBUA** includes non-lethal weapons, precision weapons, and surveillance as also situational awareness via communications that are effective in urban areas.

2. In a broad sense, our combat forces must be able to fight and survive better than their adversaries. **MOBUA** is unique because it is perhaps the most complex and resource intensive environment in which they will have to fight.

Elements of Operational Capability

3. Increasingly, urban centres would be the site of conflicts be it insurgency, low intensity conflict or full-scale war. **MOBUA** entails actions that features manmade infrastructure designed for habitation, economic and social activities by civilian populations and where tactical operations would be complicated by proximity of non-combatants. These operations would involve small subunits, where the chances of casualties of the troops would be high – hence, the importance of providing the necessary capability to the individual soldier working within a small subunit.

4. For **MOBUA** the key operational capabilities required are **firepower, force protection and manoeuvre.** C^4I and the associated situational awareness would enable each of the operational capabilities. These operational capabilities, as defined in the following paragraphs, if achieved, would significantly improve our ability to operate in an urban environment.

5. **Firepower**. This consists of a '**system of systems**' approach that enables the forces to locate an objective/target, provide responsive command and control, generate the desired effect, assess

the success achieved and retain the ability to re-engage with precision. There are two essential attributes to firepower: -

(a) **Situational Awareness** (**Intelligence**). Knowledge of enemy's and one's own position and intent is the key to success. This knowledge should be readily available at all levels down to the individual soldier.

(b) **Weapon Effectiveness**. These operations require over matching lethality in both direct and indirect firepower used to effectively engage targets commonly encountered, using smart and precision-guided munitions, in all weather conditions. Use of non-lethal weapons to minimise collateral damage must be developed.

6. **Force Protection**. We must have the ability to protect our force in an urban environment from the same technologies we intend developing or those that are likely to be used against us by our adversaries. This would enable effective employment of our forces and degrading those of our adversaries. The key to survival in such an environment is: -

(a) **Situational Awareness** (**Intelligence**). Knowledge of the precise location of the enemy is essential for efficient employment of our forces.

(b) **Weapon Effectiveness**. The ability to engage the enemy in all weather, day and night conditions before he is able to engage own forces. Use of non-lethal weapons would enable engagements without collateral damage and cater for indecision/lack of orders.

(c) **Individual Protection**. Individual systems that enhance survivability are essential since individual must survive to be successful.

7. **Manoeuvre**. Ability to accomplish the task by the multidimensional application of the force in an urban environment would be essential for a successful mission. This would entail: -

(a) **Situational Awareness (Intelligence)**. This is one ingredient that is essential for precise insertion of forces without knowledge of the enemy.

(b) **Precise Insertion**. The force must be able to approach the enemy from the **direction** he least expects and **when** he least expects – at night and in inclement weather.

(c) **Individual Mobility**. Individual warrior must be able to move quickly and precisely unencumbered by heavy and bulky body armour, weapon systems, and communication packages.

8. For the most part, the technologies necessary to achieve the operational capabilities of **MOBUA** – firepower, force protection, and manoeuvre already exist either on the shelf or are in the process of being developed both in India and abroad. The challenge is to integrate these technologies into coherent interoperable systems, which are optimised for MOBUA.

Functional Capabilities

9. **Firepower**. Improved individual and crew-served weapons with full-solution fire control, coupled with improved bunker-defeating weapon systems, will enhance target engagement capabilities against fortified, dug-in, or defilade targets. Multi-spectral sensors will provide enhanced target acquisition under all operational conditions. In addition, the appropriate sensor-to-shooter linkages will provide effective target handover to supporting standoff precision weapon systems. Non-lethal weapons such as irritants, barriers, and incapacitants will provide non-lethal capabilities for crowd control and for dealing effectively with the non-combatant population.

10. **Force Protection**. Improved small-arms protective vests will stop 7.62-mm armour-piercing rounds. Multi-spectral signature-reducing materials and techniques will reduce detection by enemy sensors. Lightweight, multi-functional protective materials will allow survival in flame and fires and other environmental threats and hazards. Combat identification, indirect viewing/unexposed firing, mine detection, anti-sniper and counter-sniper systems, and personnel status monitoring will also enhance survivability, as also

result in overall improvements in situational awareness, particularly when digitally linked.

11. **Manoeuvre**. Self-contained navigation technology capable of better than 3-meter accuracy for GPS augmentation, urban databases and digital mapping (better than 1-meter resolution), and simulations fed by the rapid generation of terrain, feature, and building data, will provide increased command response, control, intelligence, and ability to undertake mission planning and rehearsal, while enhancing manoeuvrability of individuals and the force. Precision clandestine personnel aerial delivery technologies capable of providing 25-meter CEP accuracy will heighten warrior mobility and survivability. Lightweight, rapidly emplaceable individual mobility tools will enhance the warrior's ability to move vertically and horizontally in and around buildings and other obstacles. These tools need to be offered in a variety of capabilities such as stealthy emplacement and a rapid shoot-through mode in order to defeat obstacles, open barriers/walls, and attack fortifications in an urban environment.

Way Ahead

12. Our research organisation must take the initiative in developing path-breaking technologies, which are required for urban area operations. The requirement of the systems/technologies by the Services in these areas would be fairly consistent; hence technologies so developed will find many users. Some of the areas / technologies that could be pursued are as follows: -

(a) Multi-channel RF links.

(b) Wireless networking.

(c) Data compression technologies.

(d) Real – time video including use of helicopters.

(e) Lightweight power technologies.

(f) Electronics packaging.

(g) Low-power electronics.

(h) Micro Electro-Mechanical Systems (MEMS).

(j) Advanced, lightweight multi-spectral sensors.

(k) Advanced man-machine interfaces.

(l) Automated artificial intelligence-assisted sensor/data fusion.

(m) Systems miniaturisation technologies.

(n) High – bandwidth datalinks.

(p) Smart remote/ground station processing with ATR.

(q) Low-cost millimetre-wave radar.

(r) Projectile detection/tracking algorithms processing.

(s) Laser propagation.

(t) RF antenna design/construction.

(u) RF spread – spectrum signal transmission and processing.

(v) Accurate, all-environment laser ranging techniques.

(w) Low-observable transport platform with short or vertical take-off and landing capabilities.

(x) Voice controlled communication and non-distracting control mechanisms.

(y) Advanced materials.

(z) Miniaturised propulsion.

(aa) Biomechanics and robotics.

(ab) Lightweight, long-life power sources.

Conclusion

13. The accomplishment of the mission requires integration of capabilities into a '**system of systems**'. Some of the technologies necessary to achieve the operational capabilities of **MOBUA** i.e. firepower, force protection, and manoeuvre already exist either on the shelf or are in the process of being developed in India and abroad. **The challenge is to integrate these technologies into coherent interoperable systems optimised for MOBUA.** The successful implementation of developed technologies will result in substantial improvements in our ability to effectively and efficiently accomplish their mission – whether in insurgency, low intensity conflict or full-scale war and particularly with reference to operations in built-up areas.

COMBATING TERRORISM

Introduction

1. Force protection is the security program designed to protect personnel, family members, facilities, and equipment, in all locations and situations. Force protection is accomplished through the planned and integrated application of counter terrorist operations , physical security, operations security, and personal protection, and is supported by intelligence, counterintelligence, and other security measures.

2. Combating Terrorism is a matter of high priority. The number of incidents of national and international terrorism has increased, and, the number of deaths associated with such incidents has increased manifold in recent year.

Operational Capability Elements

3. Essential operational capabilities for combating terrorism can be incorporated into three principal categories **prevention, protection,** and **response**.

Technology Development Requirements

4. **Entry Point Screening**. Involves the development of improved technical means for screening personnel, automobiles, and cargo vehicles for the presence of dangerous materials, particularly commercial, military and improvised explosives; and chemical, biological, and nuclear threat agent materials. New capabilities for detecting humans hidden in vehicles also need to be developed.

5. **Surveillance and Tracking**. Will lead to the development of advanced standoff audio and visual surveillance systems providing improved capabilities for identifying, monitoring, and tracking individual terrorists in the field. New, through-wall surveillance capabilities enabling reliable discrimination between hostiles and non-hostiles in a hostage barricade situation also need to be developed.

6. **Infrastructure Protection**. Will support the development and demonstration of advanced analytical tools for defining and mapping critical elements of the defence infrastructure, identifying and characterising potential vulnerabilities to those elements, determining associated risks and potential consequences, and defending against attacks involving either physical or electric means.

7. **Stand-off Detection of Explosives**. Will lead to the development of advanced techniques and specialised equipment enabling the detection and characterisation of a variety of explosive compositions at standoff distances ranging from very short distance (<1 meter) to as much as 100 meters or more. Approaches for detecting both solid and vapour phases of explosives that are independent of concealment and access geometries will be explored, and technologies enabling the detection of explosive device components – including detonators, switches, power supplies, and wires will be developed.

8. **IED Countermeasures**. Supports the development of new equipment and systems that will enable soldiers to safely access large vehicle bombs and other Improvised Explosive Devices (IEDs), conduct diagnostic procedures, and render them safe for subsequent handling and disposal. This work must include the development and testing of both precision and general explosive device disruption techniques.

9. **Structural Blast Mitigation**. Must provide new techniques for mitigating shock effects and damage in structures, improved building design and refortification methods, and advanced vulnerability-assessment tools for evaluating and reducing the effects of explosive blasts on structures. The work should focus on reducing debris hazards (the major cause of injuries to personnel in terrorist bomb attacks) and on preventing structural collapse (the major cause of fatalities).

10. **Chemical / Biological Countermeasures**. Supports the development of improved capabilities for detecting and identifying various chemical and biological agents prior to or after their deployment. The effort must include the development of a time-amount profile dosimeter for measuring individual exposures, new methods and materials for mitigating agent effects, and appropriate medical care and cleanup procedures.

11. **Tactical Operations Support**. Will contribute to the development of advanced technological capabilities, equipment required by military forces responsible for the planning and execution of antiterrorists and counter terrorist operations. Specific efforts must include developments involving advanced sensors, weapons, information and communications systems, targeting systems, and improved protective measures for tactical forces.

12. **Automated Terrorists Incident Indications and Warning**. Must develop an automated profiling capability and a system architecture for scanning large databases and providing leads and information linkages regarding potential terrorists activities and plans prior to the actual occurrence of anticipated incidents. Development of such capabilities will enable our forces to implement suitable protective measures and – when sufficient information is available – to execute appropriate counter-terrorist actions to prevent expected attacks. These capabilities will also direct personnel to take protective actions to remove themselves from the effects of the terrorist attack.

13. The technologies required for combating terrorism include technologies required in the areas of **Information Superiority, Military Operations in Built-Up Area (MOBUA), and Chemical/Biological Warfare Defense and Protection and Counter Weapons of Mass Destruction**. Effectively integrating the numerous and diverse activities involved in developing required new capabilities for combating terrorism into a manageable technology plan represents a formidable challenge.

Conclusion

14. The operational capabilities and technologies required to combat terrorism reflect the dynamic and diverse nature of terrorism itself. Emphasising the critical priority of force protection, the technology investments addressed in this plan cover the full spectrum of CT objectives: deterrence of terrorist incidents, employment of countermeasures, mitigating the effects of terrorist incidents, and incident recovery. The associated Research and Technology programmes must demonstrate and evaluate a wide range of many promising technology opportunities for improving our capabilities for combating terrorism.

15. Combating Terrorism leverages limited resources and focuses on technologies that offer significant improvement in Force Protection capability. Evolutionary development is the preferred approach in order to quickly field required capabilities that provide an adequate solution in the near-term but offer clear potential for upgrade as technologies mature. Successful execution of the wide range of R&D efforts cited in this plan will greatly improve the capability of the soldier by reducing the terrorist threat to the nation.

NUCLEAR, CHEMICAL AND BIOLOGICAL WARFARE DEFENCE AND PROTECTION

Introduction

1. India needs to evolve a strategy of its own against NBC threats posed to its national security. SE Asia is thus besieged with nuclear, chemical and biological warfare reality. Presence of chemical and biological weapons in the region is also known to persist. Accordingly, a need exists to utilise technology revolution for developing and mastering the 'core technologies' in this field for use by the Armed Forces.

Desired Goals

2. The following could be defined as the desired 'Goals' to attain the Joint Warfighting Capability, in an NBC environment: -

(a) Small, light-weight equipment for rapid detection and characterisation of all threat agents.

(b) Rapid, all-agent detection and characterisation.

(c) Lightweight, on the move detection.

(d) High-value site defence.

(e) Early warning of NBC attack.

(f) Tracking of threat agent clouds.

(g) Fully integrated, interoperable, joint service, real-time warning, reporting, and mapping of all CB hazards.

(h) Maintain technological capability to meet present requirements and counter future threats.

(j) Individual-level prevention and protection to preserve fighting strength; provide medical management of chemical casualties to enhance survival to expedite and maximise return

(k) Prevent casualties by use of medical countermeasures.

(l) Diagnose diseases with forward deployable kits and confirmation kits.

(m) Ensure ability to sustain operations and accomplish mission in a NBC contaminated environment.

(n) By above measures, sustain effectiveness of our armed forces for operating in a conventional scenario in the backdrop of NBC environment.

Operational Capabilities in NBC Warfare Defence and Protection

3. The key operational capabilities in NBC Warfare Defence and Protection are established as follows: -

(a) Contamination avoidance, including the ability to detect, identify, and warn of NBC attack.

(b) Protection, which encompasses individual, collective, and medical protection.

(c) Decontamination.

Functional Capabilities – Countering Chemical, Biological Warfare Defence Threats and Protection

4. **Identification and Characterisation Sensors**. Having analysed information and characterisation requirements and development, it is necessary to understand that these priorities vary across the following three sets for examining the counter-proliferation operations: -

(a) Fixed, on the ground, or shallow buried.

(b) Fixed, deeply buried, or otherwise hardened.

(c) Mobile.

5. For all the above three sets, sensors must be capable of accurately and promptly detecting critical changes in target status e.g. initiation of weapon-related activities at a fixed site: preparations for movement of mobile systems to the field. Because conventional munitions have a very limited radius of effectiveness, sensors must provide target information that has high resolution and fidelity. Given the limitations of potentially available signatures associated with these targets and activities, there would be a need to undertake challenging long-range sensor development and application efforts. Long-range options would be necessary, provided our planners envisage the need for offensive capability to destroy these weapons. However, purely in the Indian context, the need and efficacy of such unilateral offensive capability needs detailed analysis.

Technology Requirements.

6. For Point Detection, the technological issues are: -

(a) Development of real-time detection of nuclear and biological materials (current capabilities are inadequate to detect and identify these agents).

(b) Unique identification of NBC materials.

(c) Improved sampling and collection technologies for warfare agents.

(d) Small, lightweight NBC detectors (current capabilities provide limited detection but are not useful for use by an individual).

(e) Decrease in false alarm rate.

7. For Early Warning, the technological issues are: -

(a) Discrimination of biological warfare agents from each other and from naturally occurring biological materials in the atmosphere.

(b) Size, weight, and power requirements of chemical and biological detection systems (meeting these constraints may require tradeoffs in range and sensitivity).

(c) Aerosol background (naturally occurring biological materials such as pollen may cause high false alarm rates for bio-detection systems.

(d) Man-machine interface.

(e) Sensor integration on various platforms (e.g. UAVs).

(f) On-the-move standoff detection of nuclear, chemical and biological agents.

(g) High sensitivity standoff detection systems.

8. For Warning and Reporting, the technological issues are: -

(a) Digitisation of battlefield sensor information.

(b) Automation of detection and warning processes.

(c) Collation and display of relevant information at various command levels.

(d) Integration of other sensor information such as geo-location and meteorology.

(e) Integration of data into appropriate models for analysis and presentation.

9. For Individual Protection, the technological issues are: -

(a) Development of materials that reduce heat and other stress burdens on the warfighter and are more selective in precluding transport of agent across the ensemble barrier but pass heat and perspiration.

(b) Provision of clear criteria for dexterity, tactility, and mobility requirements.

(c) Provision of masks that can be adapted to a number of specialised applications on land, at sea or in air.

10. For Collective Protection, the technological issues are: -

(a) Development of longer lifetime filters/filter materials for collective protection shelters.

(b) Development of regenerative filter processes and materials.

11. For Medical Protection, the technological issues are: -

(a) Development of vaccines against NBC agents.

(b) Development of acceptable testing protocols for vaccines to determine vaccine efficacy.

(c) Development of improved tropical skin decontamination material.

(d) Development of prophylaxes against nerve agents and vesicants.

12. For Decontamination, the technological issues are: -

(a) Development of an environmentally safe, rapid acting, less corrosive, non-aqueous-based decontamination material.

(b) Development of technologies and operational doctrine for restoration of operations at critical area of fixed site facilities such as Consecrations Areas, naval ports and forward/major airfields.

(c) Provision of technologies for decontamination for sensitive closed areas and sensitive equipment.

(d) Development of standards for low-level, long-term exposure to NBC agents.

Conclusion

13. In the existing geo-political scenario, Indian armed forces will need preparations for operating in the NBC threat scenario. Unless, our 'Joint' capabilities are substantially and in a focused manner enhanced with a clear vision for harnessing the existing and the emerging core technologies, the gap between the 'capability' and our 'ability to undertake assigned missions' would continue to grow.

LOGISTICS SUPPORT

Introduction.

1. The science of planning and carrying out movement and maintenance of forces and in its most comprehensive sense the aspects of military operations which deal with the design & development, acquisition, storage, movement, distribution, maintenance, evacuation, and disposition of material; movement, evacuation and hospitalisation of personnel, acquisition or construction, maintenance, operation and disposition of facilities; and acquisition or furnishing of services.

Technology Enabling Areas

2. Developing Support Technology should allow combatants of the future movement across the battlespace with near impunity, by day, night, all weather, all terrain, against virtually any threat. There are many contemporary technologies, some of them futuristic that would be the key to making the vision of RML a reality. These are: -

(a) Sensors.

(b) Diagnostics/Prognostics.

(c) Source Data Automation.

(d) Sentinel Systems.

(e) Intelligent Networks.

(f) Natural Language Processors.

(g) Voice Activated Automation.

(h) Advanced Materials.

(j) Robotics.

(k) Smart/Brilliant Munitions.

(l) Artificial Intelligence.

(m) Satellite Communications.

(n) Advanced Manufacturing.

(p) Space Operations.

(q) Biomimetics.

(r) Nanotechnology.

(s) Micro-miniaturisation.

(t) Fuels.

R&D Focus Areas

3. Key Information technologies that rapidly and automatically identify and track assets: -

(a) Technologies such as battlefield visualisation and situational awareness.

(b) Climatically controlled, unattended, tamper-proof, smart containers.

(c) Smart delivery replenishment systems for early entry and re-supply.

(d) Built-in, self-prognostics that predict potential failures automatically.

(e) Self-healing sub-systems providing capability to delay repairs and not affect battle.

(f) Smart materials that self-heal and change according to battlefield demands.

(g) Alternative propulsion systems and fuels.

(h) Sensors and Artificial Intelligence enabling replenishment and repair movement in battle with high degree of impunity.

(j) Logistics survival in the battlefield.

Distribution Technologies

4. Some technologies that could be developed to enhance distribution: -

(a) Information-based distribution on the basis of anticipated demand.

(b) Embedded sensors and real-time situational awareness.

(c) Advanced airlift and fast sealift.

(d) Precision GPS delivery systems.

Other Technology Driven Systems

5. Multi-spectral protective fabrics for personal clothing to enhance agility.

6. Advanced Field Medical Support to continuously monitor the health of individuals, assess and predict personnel readiness in near real-time. Detect and alert medical personnel of casualty events, provide non-invasive, computer-aided diagnostic and patient monitoring capability and decision support for medics performing emergency resuscitation and provide an intensive care life-support system for casualty stabilisation and use during evacuation.

Technology for Weapon Support Systems

7. There is a requirement to look at Human Systems Interfaces and develop related technologies. Technology to improve air force sustenance logistics in areas of supportability, deployment and affordability, which would facilitate the air force to have a flexible, agile and fast response logistics infrastructure to achieve the goals of agile combat support and lean logistics. R&D is needed to develop new techniques to ensure the required support for future air/space based operations, some of which are: -

(a) Automated Generation of Technical Data.

(b) Advanced material and cargo handling equipment.

(c) Miniaturised multi-function facilities for operating from bases with minimal support equipment.

Next Generation Dry Cargo Ships

8. Future Naval specific requirements could examine technologies necessary for next generation supply ships. The objective should be to look at the design of supporting ships at sea, which would reduce manpower needs and utilise technology instead. The following technologies should be addressed: -

(a) Telecommunications and computing technologies for planning, tracking and controlling material movements.

(b) Modelling and Simulation for operational decision support.

(c) Automatic Identification Technology (AIT) for marking and locating items.

(d) Automated stowage planning for both logistics ships and combatants.

(e) Automated onboard material handling.

(f) Packaging both for war fighter ready distribution and minimisation of waste materials and the use of inter-modal containers, which can be transported efficiently by truck/rail/ship and in some cases also by air.

Conclusion

9. Effective logistics support is the fusion of information, logistics and transportation technologies to provide rapid crises response, to track and shift assets even while enroute, and to deliver tailored logistics packages and replenishments directly at the strategic, operational, and tactical level of operations. There is a requirement for a logistics system that is responsive, flexible and precise, and an environment where the military services and defence agencies work with the civilian sector to take advantage of modern business practices, commercial economies, and global networks.

10. Technologies should be pursued to enhance airlift, sealift and pre-positioning capabilities to lighten deployment loads, assist pinpoint logistics delivery systems and extend the reach and longevity of systems currently in the inventory. The combined impact of these improvements would be a smaller and more capable deployed force that would require less continuous support and have a smaller logistics footprint, and hence decrease the vulnerability of logistics lines of communication.