e-TACHYON

A TECHNOLOGY DIGEST

MAR 2023

VICTORY THROUGH TECHNOLOGY

EDITORIAL COMMITTEE

"THE **e-TACHYON** IS AN IN-HOUSE E-MAGAZINE FOR EXCHANGE OF INFORMATION RELATED TO MODERN MILITARY TECHNOLOGY. THE VIEWS EXPRESSED IN THE E-MAGAZINE ARE THE AUTHORS PERSONAL PERSPECTIVE AND DO NOT REFLECT THE OUTLOOK OF THE INSTITUTE OR THE ARMED FORCES IN ANY MANNER".

FEEDBACK

ARTICLES AND ANY OTHER KIND OF SUPPLEMENTS CAN BE SENT TO THE EMAIL GIVEN FOR FUTURE COMPILATION FROM ALL STAFF AND OFFICERS UNDERGOING VARIOUS COURSES.

eMAIL: **dstsc.af@gmail.com**

1. E-TACHYON IS A BIANNUAL E-DIGEST CIRCULATED THROUGH ELECTRONIC MEDIA, PUBLISHED BY AIR FORCE FACULTY AT MILIT. IT COVERS WIDE RANGE OF TOPICS RELATED TO MILITARY TECHNOLOGIES AND WARFARE INCLUDING EMERGING TRENDS IN STRATEGIC, OPERATIONAL AND TACTICAL ENVIRONMENT.

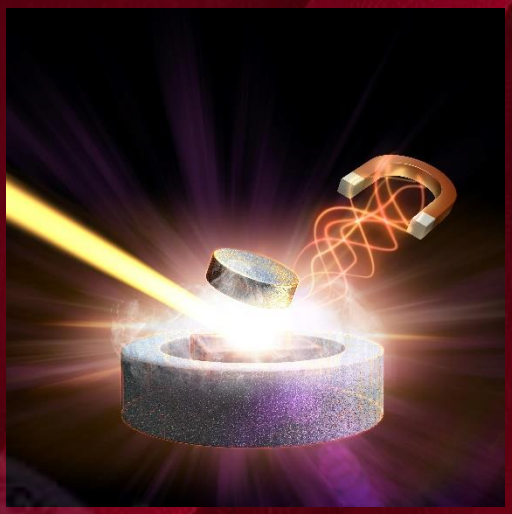
2. EXEMPLIFYING THE AFORESAID SAYING, AUTHORS OF ALL THE ARTICLES IN THIS ISSUE OF E-TACHYON, HAVE BRAVED ALL THE PREVALENT CHALLENGES TO ARRIVE AT MILIT FROM ACROSS THE LENGTH AND BREADTH OF THIS VAST NATION TO UNDERGO DSTSC (AF)-05. OUR PRESENT ISSUE IS A BALANCED MIX OF ARTICLES FROM VARIOUS TECHNOLOGICAL FIELD INFLUENCING BATTLEFIELDS OF PRESENT DAY AND THAT OF FUTURE.

3. THE MAGAZINE ENDEAVOURS TO BRING OUT THE LATENT CREATIVE SKILLS OF STUDENT OFFICERS AND HELPS THEM TO FORM THE HABIT OF READING AND WRITING. IT ALSO HELPS THEM TO HONE THEIR INTELLECTUAL SKILLS AS WELL AS BENEFITS IN WIDENING THE HORIZONS OF KNOWLEDGE. THIS GIVES A CHANCE TO THE OTHER STUDENT OFFICERS TO BE INSPIRED BY THEIR PEERS, EXPERIENCE.

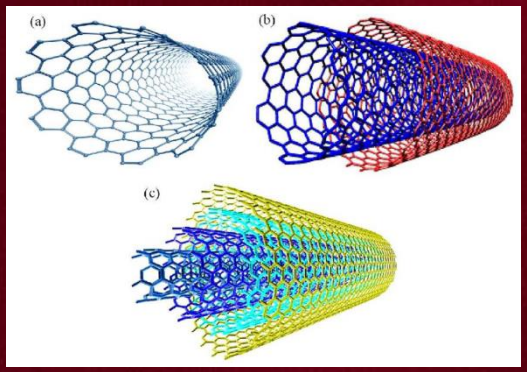
4. THE ZEAL FOR LEARNING AMIDST ALL DIFFICULTIES AND ABILITY TO EMBRACE EMERGING TECHNOLOGIES IS AMPLY CLEAR FROM THE PERTINENT TOPICS FOR ARTICLES.

HAPPY FLIPPING

CONTENTS



CONTENTS



SUPERCONDUCTIVITY: A ROADMAP FOR INTEGRATION OF SUPERCONDUCTORS WITH NAVAL PLATFORMS

COMPILED BY

CDR AMIT KUMAR DALAL, DSTSC-05 (NAVY)

INTRODUCTION

1. Ever since superconductivity was discovered in 1911 by Kamerlingh Onnes, there has been a flurry of scientific research on the subject as well as attempts to introduce a commercially viable application. Improvements in cryogenic technology have provided a significant stimulus towards these attempts. Additionally, the advent of High Temperature Superconductors (HTS) has opened new avenues in Material Science, Manufacturing Processes and Electrical Engineering. This paper is an effort to instruct on the basics of Superconductivity, history of Superconductivity, current trends, naval applications and advantages of the technology over existing technologies.

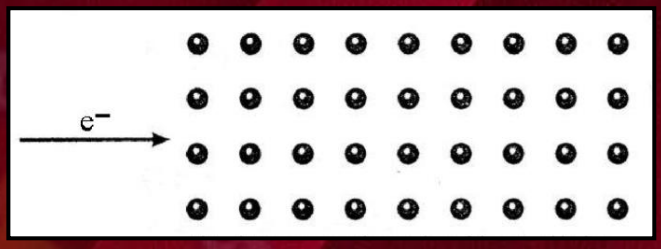
THEORY OF SUPERCONDUCTIVITY

2. Superconductivity can be defined as a macroscopic quantum phenomenon in which certain materials known as superconductors exhibit perfect conductivity and perfect diamagnetism when cooled below a certain temperature called as critical temperature T_c. A mathematical treatment of superconductivity is beyond the scope of this paper. Although, the BCS Theory is the best explanation of superconductivity in Low Temperature Superconductors, it is unable to explain the same phenomenon in HTS. However, BCS theory provides the best explanation for vanishing of electrical resistance below critical temperature T_c.

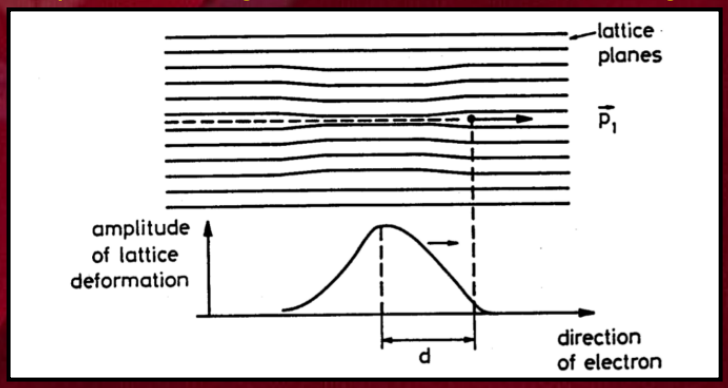
3. Electrons can be deflected by means of electric and magnetic fields, and they can be thermally evaporated from metals (glowing cathode). All these are processes where the electrons are described in terms of particles. However, Louis de Broglie proposed the hypothesis that each moving particle also represents a wave, where the wavelength λ is equal to Planck's constant '*h*' divided by the magnitude '*p*' of the particle momentum i.e., $\lambda = h/p$. With electrons we can observe diffraction and interference effects. Similar effects also exist for other particles, say, for neutrons. For the matter wave associated with the moving particle, there exists, like for each wave process, a characteristic differential equation, the fundamental Schrödinger equation. Hence, electrons moving within a metal also represent waves.

4. The mechanism generating electrical resistance can be explained by treating electrons as waves rather than particles. The electrons are described in terms of waves propagating in all directions through the crystal. An electric current result if more waves propagate in one direction than in the opposite one. The electron waves are scattered because of their interaction with the atomic ions. This scattering is like collisions between electrons and ions when we visualize electrons as particles. The scattering cannot take place for a strongly periodic crystal lattice. Only a perturbation of the periodic potential, caused by thermal vibrations of the atoms, by defects in the crystal lattice or by chemical impurities, can lead to a scattering of the electron waves. The scattering due to the thermal vibrations yields a temperature-dependent component of the resistance, whereas that at crystal defects and chemical impurities yields the residual resistance. Thus, the temperature dependence of resistance can be explained.

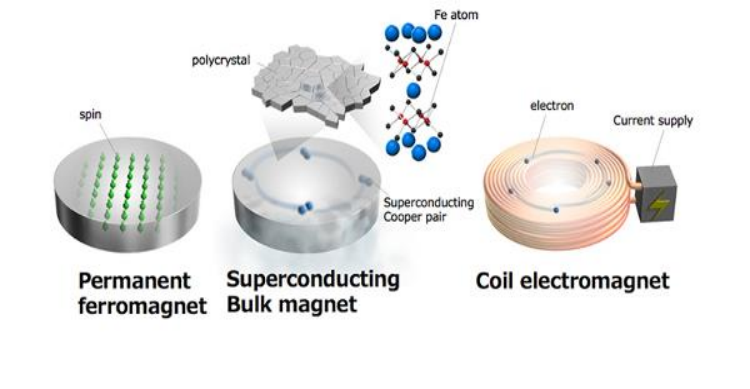
5. A microscopic theory of superconductivity was developed in 1957 by John Bardeen, Leon Cooper and J. Robert Schrieffer, which is known as the BCS theory. The central feature of the BCS theory is that two electrons in the superconductor are able to form a bound pair called a Cooper pair if they somehow experience an attractive interaction between them. This notion at first sight seems counterintuitive since electrons normally repel one another because of their like charges.



6. The first electron flies through the lattice and attracts the positive ions. Because of their inertia they cannot follow immediately, the shortest response time corresponds to the highest possible lattice vibration frequency. Obviously, the lattice deformation attracts the second electron because there is an accumulation of positive charge. The attraction is the strongest when the second electron moves right along the track of the first one and when it is at a distance ‘d’ behind it as shown in Figure 2. This explains why a Cooper pair is a much-extended object; the two electrons may be several 100 to 1000 lattice constants apart. For a simple cubic lattice, the lattice constant is the distance between adjacent atoms.



7. Interaction between electrons and lattice atoms is critical for the existence of superconductive state. This is the reason that good conductors like copper are poor superconductors. Thus, electron pairs and no single electrons, are charge carriers in superconductors. The electron-electron coupling is weak and can be destroyed by thermal motion of the lattice. For this reason, superconductivity exists only at low temperatures. Large number of Cooper pairs can populate one collective state.



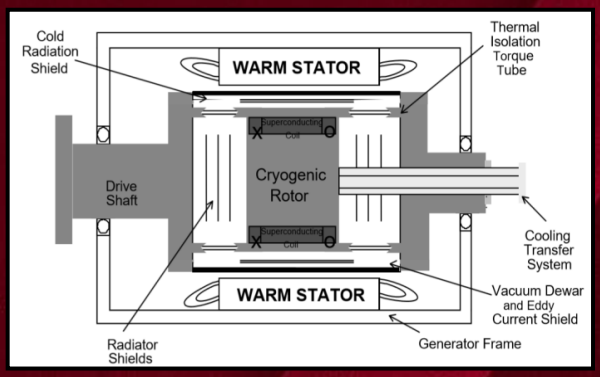
8. This state is stable and requires some additional energy input (thermal energy) to be destroyed. The formation of collective state of Cooper pairs take place at $T<T_c$. In the collective bound state, the Cooper pairs do not scatter from the lattice and the conductivity of superconductor is infinitely large. Scattering of electrons from the lattice atoms require a change of state of electron.

CURRENT TRENDS

9. The first large scale commercial application of superconductivity was in Magnetic Resonance Imaging (MRI). This is a non-intrusive medical imaging technique that creates a two-dimensional picture of say tumors and other abnormalities within the body or brain. This requires a person to be placed inside a large and uniform electromagnet with a high magnetic field. Although normal electromagnets can be used for this purpose, because of resistance they would dissipate a great deal of heat and have large power requirements. Superconducting magnets on the other hand have almost no power requirements apart from operating the cooling system. Once electrical current flows in the superconducting wire, the power supply can be switched off because the wires can be formed into a loop and the current will persist indefinitely as long as the temperature is kept below the transition temperature of the superconductor.

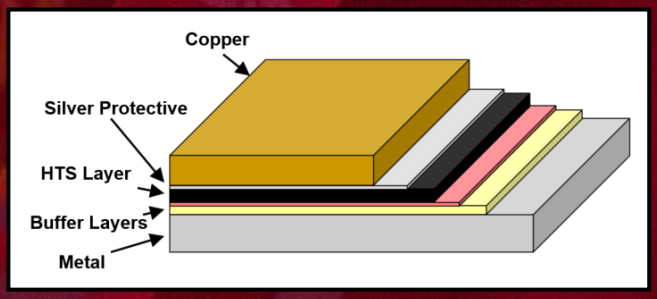
10. Superconducting Quantum Interference Device (SQUID) is an extremely sensitive magnetic field sensing device that is capable of detecting magnetic fields of the order of 10^{-13} Tesla. These devices can thus sense magnetic fields created by the heart and brain for non-intrusive medical diagnosis. Magnetic Levitation (Maglev) is another application where powerful superconducting magnets are used to levitate high-speed trains while pulling the trains forward.

NAVAL APPLICATIONS



11. **HTS Generators**. Superconducting AC synchronous generators work by electromagnetic induction. They usually incorporate the superconducting wire into the rotor field windings while retaining a non-cryogenic armature which employs standard copper windings. The stator has a conventional design using copper windings except for the elimination of the iron. In the rotor windings, the superconductor will generally experience a DC field, thus AC losses are kept to a minimum and largely due to asynchronous feedback.

12. **HTS Conductors**. HTS conductors typically take the form of a thin tape, allowing them to be bent around relatively small diameters into high density coil windings. The first HTS conductor viable for applications was the Bismuth-based superconductor. The newer HTS Conductors are YBCO (Yttrium Barium Copper Oxide) based which are also known as 2nd Generation HTS Conductors. These conductors have substantial advantages over 1st Generation HTS conductors. One of the primary advantages of YBCO is the possibility of liquid nitrogen temperature (77 K) operation, which would result in substantially relaxed cooling requirements. These conductors can sustain high current densities in fields upto several Tesla. Substantial reduction in AC losses, superior strain tolerance and lower cost are further benefits of 2nd Generation HTS Conductors. However, there are still challenges to overcome to minimize AC losses which include ferromagnetic, eddy current and coupling current losses.



13. **HTS Motors**. The large size and heavy weight of conventional copper-based electrical propulsion motors and generators has been a barrier to broad adoption of electric propulsion. For these reasons, superconductors offer additional, important advantages for electrically propelled ships. HTS motors are much smaller and lighter; operating prototypes are one-third the size and weight of their conventional copper-wound counterparts and quieter. The elimination of rotor losses results in much higher efficiency, especially under partial-load conditions, where many ships operate for the great majority of their operating hours. This improved efficiency translates into a longer cruising range and greater fuel economy. Smaller propulsion motors translate into naval ships that can carry more powerful weapons such as high-power combat radars and additional missiles.

14. **HTS Degaussing System**. In a pilot project implemented on a US Navy warship, USS Higgins, the existing degaussing cables in the stern section of the ship were replaced with Superconducting HTS cables. Trials of the same were successful. Superconducting degaussing systems are advantageous since relatively thin, lightweight cables are capable of carrying sufficient high density current in order to nullify the ship's magnetic signature.

15. **Integrated Power System (IPS)**. IPS is the final stage in the migration towards complete adoption of superconductivity on-board naval warships. The IPS consists of an architecture which provides the basis for designing, procuring and supporting marine power systems.

CONCLUSION

16. The employability of superconductivity in naval applications has already begun in the form of various trials. Superconductors hold immense potential and have myriad advantages, some of which have been outlined as under: -

(a) **Reduction in Size and Weight**. All future superconductive machines will substantially reduce size and weight compared to the conventional machines. The reason is the small size of HTS conductors required to realize HTS motors, generators and HTS cables.

(b) **Elimination of Iron Cores to couple Magnetic Fields**. Use of iron cores for coupling strong magnetic fields in transformers and electromagnets is eliminated by the production of high Tesla magnetic fields by superconductors.

(c) **High Current Densities** The current densities of YBCO HTS Conductors are of the order of which is extremely high compared to that of most widely used copper conductors.

(d) **High Magnetic Fields**. Superconductors can produce the strongest magnetic fields of up to 20 Tesla with negligible heat dissipation. No other technology can produce such fields at economical costs.

(e) **Zero Resistance to Current**. The fundamental property of Superconductivity is yet to realize further potential. Complete power grids can be powered in the future through HTS power cables with no losses.

(f) **Reduced Environmental Impacts**. Liquid nitrogen is readily available, clean, non-hazardous and has no adverse environmental impacts.

HARNESSING ARTIFICIAL INTELLIGENCE WARFARE FOR WARFARE AT SEA BY INDIAN NAVY

COMPILED BY

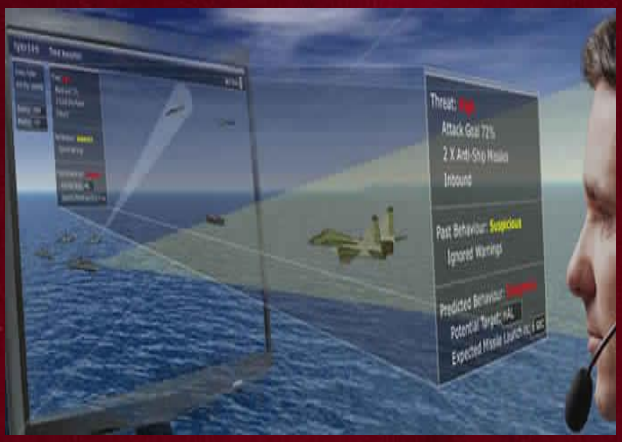
CDR KUNAL LELE, DSTSC-05 (NAVY)

INTRODUCTION

1. Artificial intelligence (AI) also known as machine intelligence (MI) is intellect displayed by computer system (or machine), in contrast with the natural intelligence (NI) displayed by humans and other animals. A general definition of AI is the capability of a machine to perform tasks that normally require human intellect, such as visual perception, speech recognition and decision-making. Understanding the nuances of AI, entails understanding the difference between an automated and an autonomous system. An automated system is one in which a computer reasons by a clear if–then–else, rule-based structure, and does so deterministically, meaning that for each input the system output will always be the same (unless if something fails). An autonomous system is one that reasons probabilistically given a set of inputs, meaning that it makes guesses about best possible courses of action given sensor data input. Unlike automated systems, when given the same input autonomous systems will not necessarily produce the exact behaviour every time rather, such systems will produce a range of behaviours.

APPLICATION OF AI IN INDIAN NAVY

2. Various countries have placed considerable importance on developing military uses of AI to maintain battle-space superiority. AI-based technologies can be employed in the military domain to execute complex missions, especially in environments that are hostile and unpredictable. The maritime battlespace perfectly fits this frame. Oceanic environments are often unmapped and difficult to navigate, and the use of AI-based systems to track, calculate, detect, chart and execute the best actions for a vessel augments existing nautical capabilities. In operating locales that need constant intelligence, surveillance and reconnaissance of the ocean environment, AI-supported systems can negate the hostilities of marine physics, i.e., hydrostatic pressure, ocean turbulence, thermal gradient, and ocean salinity, among others.



ARTIFICIAL INTELLIGENCE IN NAVAL COMBAT SYSTEMS

3. The purpose behind the application of AI to naval operations through information management systems is to influence and augment the decision-making process of the naval commander. The practice of using digital assistants for enhanced navigability is not a new concept in naval vessels, but the ground-breaking aspect of the next step in naval combat systems is their ability to revolutionise command and control of an entire vessel, or even an entire fleet. The AI software gives command teams the ability to monitor real-time combat situations and suitably utilise the naval assets at their disposal. These systems combine hardware and software (processes) to completely transform naval manoeuvres.

4. These systems can even enhance fleet operability, given assets are connected to each other. The Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) oriented system can be connected to individual naval vessels, irrespective of their class. Submarines, frigates, aircraft carriers, battleships, unmanned vehicles can all be equipped individually with such systems to augment their specific functions. Unmanned assets connected to the system with the ability to relay back intelligent video analytics will be able to provide over-the-horizon (OTH) mapping and targeting, extending the line-of-sight of the fleet in all directions.

AREAS OF APPLICATION OF AI IN WARFARE

5. It is evident that AI can be gainfully utilized to integrate C4ISR capabilities and works towards deeper fusion of systems and sensors across all domains of warfare. The results of informatisation have created new challenges in the effective processing and utilization of data which in turn will enhance situational awareness and the speed of battle field decision making. Few areas of military AI application are listed in succeeding paragraphs.

6. **Computational Military**. Reasoning Computational military reasoning is a computer solving human-level military problem and concentrates on tactical artificial intelligence or battlefield decisions. Tactical AI analyzes the battlefield and acts on that information by creating a set of coherent orders that exploit the weaknesses in enemy's position that were found during battlefield analysis. The said application of AI can be gainfully utilized for terrain analysis, war gaming and tactical training. Following are some of the areas of Computational Military applications.

(a) **Intelligent and Autonomous Unmanned Weapon Systems**. AI can be used in the development of Intelligent and Autonomous Weapons Systems including unmanned aerial, surface and underwater vehicles, as well as military robotics and cruise missiles. This type of weapon systems can utilises AI to automatically pursue, distinguish, and destroy enemy targets and often composed of information collection and management systems, knowledge base systems, assistance to decision systems, mission implementation systems, etc.

(b) **AI-Enabled Data Fusion, Information Processing and Intelligence Analysis**. AI can be applied for effective processing of sensor data and raw intelligence which incorporates intelligent sensing and automation of multi-sensor data fusion to enhance situational awareness. Also, introduction of deep learning algorithms into the analysis process for satellite imagery could greatly enhance the rapidity of processing. AI assisted information processing and intelligence analysis can be used for sub-conventional operations.

(c) **Cyber Defence and Cyber Warfare**. AI can be leveraged to enhance the defense of critical military networks and information systems, to scale the effects of offensive cyber operations, and to inform command decision-making in cyber warfare Distributed Denial of Service (DDoS) attacks can be detected and mitigated through pattern matching, statistical analysis, machine learning and big data analysis. Software vulnerability analysis can be based on AI “fuzzing” technique that could be used in penetration testing for offensive or defensive purposes and Intrusion detection and prevention methods can be addressed by deep neural networks. Given the speed of cyber operations, AI could serve as a critical enabler of rapid command. AI applications in cyber domain can be used by non state actors.

(d) **Cognitive Radio and Cognitive Electronic Warfare**. AI can be employed in development of Cognitive radio with dynamic spectrum management to enhance communications, while pursuing offensive capabilities in cognitive electronic warfare through the application of machine learning to learn and rapidly devise countermeasures for adversary systems. As the electromagnetic spectrum becomes ever more complex and contested, the introduction of AI will be critical to achieving an advantage.

(e) **Tactical Applications**. Few tactical applications of AI are as under:

(i) Mine sweeping drone bots that can use feature maps to analyse and identify mines, to deactivate them or carry them away.

(ii) Enemy segmentation detection, identify enemy tanks in different situations.

(iii) Combat simulations in terms of VR situations, can help train soldiers for a more realistic battle circumstance.

(iv) Combat helmets with visors that analyse battlefield environment or provide extra specific vision.

CENTRE FOR ARTIFICIAL INTELLIGENCE AND ROBOTICS (CAIR)

7. Indian AI research in defense is housed under the Defense Research and Development Organization. Primary focus areas of CAIR are artificial neural networks, computer vision, and situational awareness, and two other products that are under development for network-centric operations and decision making using a vast knowledge base of battlefield tactics data. CAIR also lists civilian applications such as experimental robots, including a machine that can play chess by leveraging an AI-based decision engine. CAIR is engaged in the development of a range of Intelligent Systems, Information Processing Systems, Tactical Command Control & Communication Systems and Security Solutions. Simultaneously, the laboratory carries out R&D in advanced technologies relevant to these classes of systems. The current thrust areas of CAIR are Net Centric Systems for Tactical Command Control & Communication Systems, Intelligent Systems, Unmanned Systems, and Information Security.

CONCLUSION

8. Artificial Intelligence (AI) is essentially a dual use technology which can fuel technology driven economic growth and has potential to provide military superiority. Given India's strong IT industry and pool of engineers, the Ministry has initiated the process of preparing Indian defence forces in their use of AI and leveraging AI capabilities to study the strategic implications of AI in the perspective of national security, a multi-stakeholder Task Force comprising the Government, Services, Academia, Industry, Professionals and Start-ups was constituted in February 2018, under the Chairmanship of Shri N Chandrasekharan, Chairman, Tata Sons to prepare a road map for AI in national security. Its Terms of Reference included a global scan of AI applications, study of level of AI development in India in general and specifically in the context of defence needs, and to make recommendations relating to making India a significant power of AI in defence, specifically in the area of naval, aviation, land systems, cyber, nuclear and biological warfare including both defensive and offensive needs including counter AI needs. Recommendations for policy and institutional interventions are required to regulate and encourage robust AI based technologies for defence sector. It entails working with start-ups / commercial industry and recommendations for appropriate strategies of working with start-ups.

RELIABILITY AND MAINTAINABILITY IN AIRCRAFT SYSTEM

COMPILED BY

SQN LDR PL YADAV, DSTSC-05 (AF)

BACKGROUND

1. In aircraft systems, reliability and maintainability are fundamental for ensuring most critical aspect that is aircraft safety and its reliability. Even though 100% safety cannot be guaranteed in aviation sector, severe & sometimes unbearable losses might be suffered e.g., human fatalities, financial losses, etc. For this reason, the aviation industry has imposed strict reliability requirements on itself. Within the aviation industry, the operational requirements are high and because of the consequences of failure, the maintenance procedures governed by strict legislation under strict directive from regulating authority. These directives are developed in a structured way of national requirements like international safety standards. The inclusion of such requirements helps to minimize life cycle costs, augments the residual lifetime of aircraft and consequently increases customer satisfaction.

2. This article discusses various concepts such as design for reliability and risk assessment analysis for improving aircraft safety and reliability at the deployment stages and maintenance operation. The article also focuses on how reliability prediction issues are addressed using various methods, tools and standards, such as failure modes and effect analysis, fault tree analysis.

INTRODUCTION

3. Modern technology has developed a tendency to design and manufacture equipment and systems of greater capital cost, sophistication, complexity, and capacity. The disastrous consequences of low availability and high maintenance cost of such systems led to the desire for high reliability, high maintainability and low mean time to repair/maintain. Due to design problems and poor product support, manufacturer equipment and systems are not able to meet these requirements. Therefore, ensuring continuous operational availability and safety has become central concern area in aviation segment which can be addressed by improving Reliability and better maintenance.

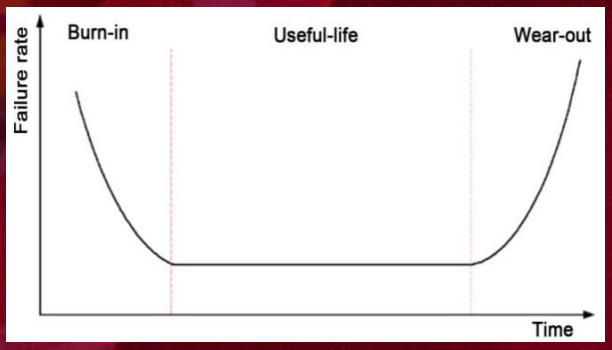
4. Generally, the operational availability and reliability would be achieved through redundancies. However, increasing redundancies means a higher number of systems need to be maintained, which in turn may cause even higher costs. Another approach to this issue is reducing the risk of failure. This second approach means a focus on increased reliability. Due to high safety concerns and expensive equipment, aviation industry is one of the leading areas in reliability.

CHARACTERISTICS OF AIRCRAFT: RELIABILITY

5. The typical life cycle of an aircraft consists of individual phases, from research, development, production and operation along with maintenance till its retirement and disposal. Ever since the very beginning of the industrial era, customers have demanded more, better and faster deliveries of products and services, all these at lower costs. In other words, they want to get value for their money spent. And operators want infinite performance, at zero life-cycle costs, with 100% availability from the day they take delivery to the day they dispose it. So, during various phases reliability and safety of the equipment should be focussed while manufacturing, operating and maintenance.

6. Reliability engineering techniques have been developed to describe the ability of a system to perform its mission under stated conditions for a specified period of time. Experimental observation considers that plotting failure rates usually gives a curve called a "bathtub curve" (Figure below). In such a case, reliability may refer to the quantification of infant mortality (Burn-in), useful life or wear-out mechanisms. During the infant mortality period, the failure rates decrease because a component's probability of failure decreases over time.

7. In aircraft life cycle engineering, reliability engineering expertise is present in almost all phases, from design to release and even after withdrawal for disassembly and recovery of components that can be reused. In aviation, the reliability function is closely related to safety engineering and system safety. They share several practices in their analysis and can be complementary. In aircraft engineering, safety engineering proposes methods and directives to safeguard life and nature. Nonetheless, reliability engineering also proposes techniques that can be of great help for identifying default causes and improving the safety of a system so that it can survive when a failure occurs under extreme conditions.



MAINTENANCE

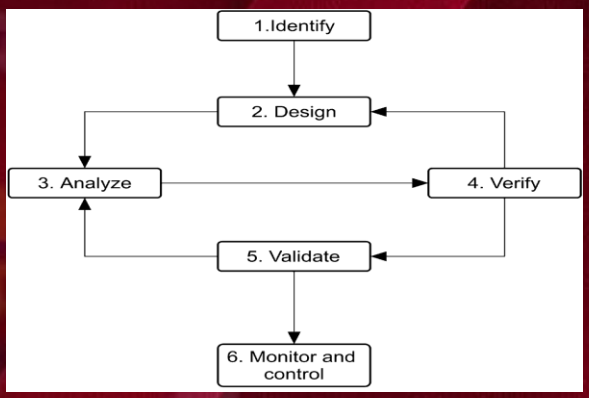
8. Maintenance is ensuring that physical assets continue to do what their users want them to do. These actions are conducted to ensure the system performs as intended, that it is reliable and safe. Being an auxiliary or support process, maintenance has no direct profitable output, however, by ensuring or even increasing production capacity it is an unavoidable part of any producing or operating process.

9. The main objective of the maintenance function is to ensure the availability of the system. Further critical failure are under no circumstances allowed to occur during flight. Broadly maintenance is divided in corrective and predictive maintenance and further preventive maintenance is divided into preventive and conditional maintenance. Maintenance is a procedure conducted on a system or its components like Overhaul, Repair, Inspection, Replacement, Modification, Defect rectification.

DESIGN FOR RELIABILITY IN THE AIRCRAFT INDUSTRY

10. Design for reliability R(t) in the Aviation industry is the process of designing reliability into products. This works as a number of techniques, methods and instruments that might be utilized within the design phase of every product or service to optimize the probability that the item can satisfy reliability demands, goals and presumptions and, as a side effect, to reduce the potential risk of having a poor item that is difficult to promote.

11. If reliability is taken care of at the design phase, the final cost of the product does not go up. If a reliability problem is detected during engineering, the cost of the product goes up by a factor of 10. If the problem is caught in the production phase, the cost of the product increases by a factor of 100 or more''. This is often the key reason why it is crucial to adhere to a detailed design program to guarantee the reliability of the aircraft. Reliability is the subject of focus at the design stage so that, if all the specifications are checked meticulously, engineers can obtain an excellent product.



RELIABILITY CENTRED MAINTENANCE (RCM)

12. The process is used to identify system functions, the way these functions fail and the consequences of the failures and apply this information to develop an appropriate maintenance task to prevent system failures. Primarily, one can say that the objective of RCM is to preserve systems functions considering objectives as minimizing costs, safety and environmental goals and finally meeting operational goals.

FAILURE MODE EFFECT ANALYSIS (FMEA)

13. FMEA helps to identify the potential failure whose consequences affect the proper functioning of the system and for estimating the risk associated with the occurrence of the failures. These failures so that the corrective action can be taken during design, implementation or exploitation phases of the system.

FMEA also known to be inductive method that can be applied to any system having risk failure and not meeting its objective of reliability, maintainability and safety. FMEAs are developed around the following points: -

(a) To postulate each failure mode based on the functional requirements

(b) To determine the appropriate effects

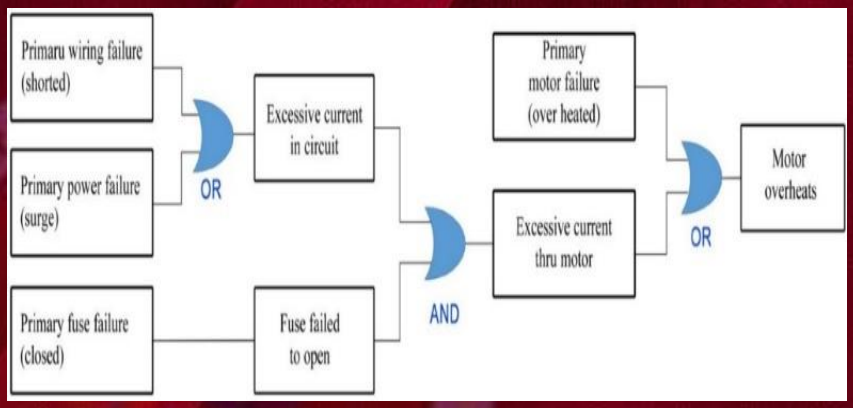
(c) To determine the severity of the effect

(d) To postulate on the possible causes

(e) Occurrence (relative probability).

FAULT TREE ANALYSIS (FTA)

14. Fault tree analysis (FTA) is a malfunction evaluation technique through which an unwanted system event is examined by using Boolean logic to incorporate a number of lower-level events. FTA is essentially composed of logic diagrams that demonstrate the condition of the machine and that are created using visual design techniques. This is a significantly more formalized top-down strategy for pin-pointing the actual causal links among functional breakdowns in addition to their antecedents in events or problems related to lower level parts. The evaluation produces a graphical portrayal of the combinations of sub-system and element failures that can lead to the system event. The fault tree uses common notations of Boolean logic to indicate precursor lower-level events that will occur individually or in combination to result in the higher level event.



CONCLUSION

16. Many serious accidents were recorded in previous decades, even though the crashed aircrafts were among the safe to fly because they respected all the security conditions imposed by international agencies for security, safety and regulation world- wide. Despite the great progress in technology and processes, there remains much to be done to reduce the number of aircraft accidents to zero. In this article We have also laid emphasis on design for reliability for organizing and analysing the different steps that consider reliability as a main activity for increasing the safety of aircraft. Reliability and maintenance area subject that contain aspects of a multitude of disciplines, and that makes the study of these subjects a complex and non-linear task. Reliability in particular has an associated level of uncertainty that should always be considered.

PRECISION GUIDED MUNITIONS (PGMs)

COMPILED BY

WG CDR B MAHANTA, DSTSC-05(AF)

INTRODUCTION

1. In every conflict there are a number of strategically important targets such as command and control bunkers, bridges, radar sites, tunnels and airfields. Since the World War II, campaign planners have looked more and more to air power to destroy or neutralise these targets. However, until the late sixties the only means available was by what are called today "Dumb bombs". Examination of Weapon Effort Planning documents will show, that to attain a relatively high level of assurance, say 80% of destroying a single bridge with dumb bombs, it would require 100 ac sorties with 4x1000 lbs each. This calculation also cannot be considered at par with the actual level of attrition and it is a fair assumption that all such strategic targets will be well defended.

ABSOLUTE NECESSITY FOR PRECISION

2. In summary, three different imperatives have made precision attack weapons absolutely essential.

(a) Least effort for aircraft (accuracy)
(b) Least attrition
(c) Unacceptability of collateral damage

3. Given that, the need to avoid collateral damage is a political imperative we as operators are more concerned about the first two necessities. Thus, it is an essential operational requirement for aircraft to be armed with weapons giving precision guidance and stand off for the surgical attack of strategically important targets. Precision guidance and standoff are essential for the surgical attack of strategically important targets.

DEFINITION

5. PGMs can be defined as any weapon, which through mid-course or terminal guidance corrects its trajectory, such that it ensures a high degree of target destruction". As covered earlier, PGMs came about due to the requirement of ensuring a high degree of destruction with a minimum of effort and risk to the launch platform. PGMs are of two types viz. Unpowered or SMART bombs and powered or standoff weapons.

CONSTRUCTION

6. A PGM is basically a dumb bomb with inclusion of a seeker head (the eyes), a control section with an autopilot and control surfaces (the limbs) which move to cause a change in the flight path.

7. **Parts of PGM**

(a) Seeker. It acquires the target/alternatively picks up the energy radiated by the target and passes on this information to the guidance and control section.

(b) Control section or Computer Control Group (CCG). The signals from seeker head are processed here. Target positions with respect of the weapon is computed and required change in trajectory/flight path is passed to the auto pilot.

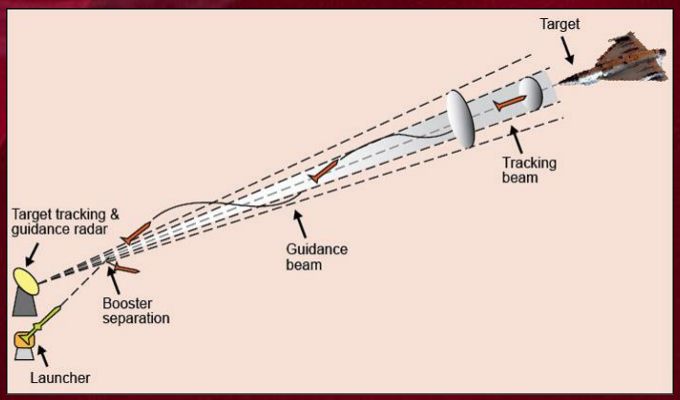
(c) Control surfaces. They are commanded by Auto-Pilot to change the flight path in such a way that target intercept is assured.

GUIDANCE SECTION

8. There are basically four types of guidance systems used PGM's:

(a) Active guidance
(b) Semi-active guidance
(c) Passive guidance
(d) Inertial guidance

9. Active guidance. Active guidance is one in which the weapon itself radiates electromagnetic energy and generates guidance commands depending on the reflected energy from the target. The types of active guidance available are Radar, LADAR and Terrain reference navigation. The weapons after initial target designation are launched, thereafter they acquire and track the target on their own without any assistance from launch platform. They have true "Fire and Forget" capability. Examples of these weapons are anti-ship missiles, BVR AAMs millimetric wave version of Maverick and cruise missiles.



10. Semi active guidance. Here the weapon homes on to the reflected energy from the tgt. The illumination has to be provided by the launch platform or an external source, where the weapon glides down the beam, in case of beam riding msl or generates angular co-ordinates and steers itself towards the tgt. Examples are, Laser guided bombs and missiles.

11. Passive guidance. This type of weapon utilises the energy radiated by the target itself. The EM energy radiated could be in the form of RF, IR or aural frequencies. A typical example is the Anti-radiation missile. The missile locks on to the EM energy of target radar and once the target is designated, the missile independently homes on the transmitting radar. Similar is the case of an IR guided weapon, which homes on the heat energy radiated by the target.

12. Inertial guidance. In this type, it uses gyro platform coupled with accelerometers to generate steering commands towards a pre-designated target.

LASER PGM OPERATION

13. Laser PGM is released from low, medium or high altitude from beyond visual range of target. After release PGM will either climb or dive to the pre-programmed hold altitude that was defined in MSN planning. Normally this is about 3000 ft, but it will depend on terrain and cloud base conditions in the target area. The weapon Navigates to the tgt area and will use the rocket motor to provide boost if required. Upon reaching the acquisition area, which is denoted by a circle in the picture, the airborne laser designator must be switched on and the seeker will search for a pre-programmed coded laser energy that was defined in MSN planning. On detection of the laser energy being reflected from the targett. PGM will lock onto it and dive to the target.

14. Upon reaching the acquisition area, again denoted here by a circle, the weapon seeker and datalink turn on automatically. The pilot can now utilise the HUD and joystick controls to accomplish man in the loop target selection. This is normally done with the seeker in wide field of view. As the WPN approaches the tgt area, the pilot will utilise the narrow field of view to refine the aiming point if required. Once locked onto a tgt the PGM is fully autonomous until impact.

MODERN DEVELOPMENTS

15. Although developments are taking place in almost every aspect of weapon development, certain stand out as offering significant new combat capabilities. These are: -

(a) New types of multimode guidance
(b) Exploitation of millimetric wave seeker heads
(c) Development of GPS based smart weapons.
(d) Weapons for the battlefield of the Future

16. Laser guided bombs (LGB's) provided a quantum jump in the effectiveness of aerial bombing campaigns. However, as a direct result, significant effort was put into increasing the ground-to-air defences in the vicinity of strategically important targets and as these defences have improved so have aircraft operator more and more seek standoff in PGM's in order to reduce attrition.

COUNTERING UAS/UAV: RECENT DEVELOPMENTS

COMPILED BY

MAJ RAJENDRA KUMAR YADAV, DSTSC-05 (ARMY)

INTRODUCTION

1. Drones are mostly unaffected by the air defence systems that have historically been employed to defend airspace from manned aircraft. Large, moving objects are typically detected by military anti-aircraft radars. As a result, they can struggle to capture tiny, slow, low-flying drones. Also, because unmanned aircraft are inexpensive, it is impracticable to shoot them down with conventional antiaircraft weapons, which can cost hundreds of thousands of dollars per unit. Even powerful air defence systems have occasionally been unable to shoot down basic unmanned aircraft. It is equally futile to rely just on visual observation to find drones because, at distances of several hundred feet, drones can virtually disappear from view.

2. Only ten specialist counter drone systems were found to be on sale in a 2015 market survey. There are currently more than 200 systems available. A study discovered that 155 manufacturers across 33 nations had at least 235 counter drone solutions either on the market or actively being developed. 3 Venture capital firms have also shown interest in the field, and US Military budget spending on counter drone technology acquisition and development is now expanding at the quickest rate. Small drones have been multiplying in the military at a rate that has concerned both planners and commanders on the battlefield.

LATEST COUNTER UAS SOLUTION

3. **X- MADIS & L- MADIS**. Ascent Vision Technologies (AVT) received a $23 million contract from the US Air Force in August 2019 to provide mobile counter drone vehicles for the expeditionary Mobile Air Defence Integrated System (X-MADIS) programme. The X-MADIS uses radar, optical, radio frequency detection, a jammer, and electronic command and control mitigation of the aircraft, whether it is stationary or in motion, to detect, locate, track, identify, and soft-kill small UAS. Recently, a variant of the MADIS family of systems, the Light Marine Air Defence Integrated System (L-MADIS) which in use by the US Marine Corps (USMC), downed an Iranian drone in the Persian Gulf as it harassed a US Navy vessel. The L-MADIS comprises two MRZR vehicles, a command node and a sensor vehicle that uses RF to jam flying drones. The capability has been deployed by marines in the US Central Command to protect convoys or protect a forward operating base with protection from UAVs.

4. **Silent Archer**. The US Army stated in January 2019 that SRC Inc, has been awarded a $108 million contract to create a vehicle integrated system for the US Army. As part of a $65 million contract, the Army initially ordered 15 sets of Silent Archer counter drone devices in 2017. In April 2018, the Air Force bought the equipment in a contract worth $57 million. In order to eliminate hostile drones, whether they are present singly or in swarms, the Silent Archer System employs a TRL 8/9 radar, Electronic Warfare (EW) systems, camera, and 3D user display.

5. **Anti Drone Ray Guns**. Radio control frequencies are used by anti-drone ray guns to interfere with commercial drones' communications, causing them to lose control and, ideally, land. Although the Pentagon is also working with similar capabilities, non-kinetic alternatives like ray guns are particularly well-liked by local law enforcement agencies that may need to shoot down drones in congested settings where kinetic weapons are not an option. The US Army issued a request for proposals in July 2019 for 40 Drone Defender Systems, which can be placed on any existing weapon with a picatinny rail. The request was made on behalf of the Counter, Rocket, Artillery, and Mortar Project Directorate.

6. **High Energy LASER**. The mobile high energy laser weapon system from Raytheon, which was delivered to the USAF in October 2019, detects, identifies, and tracks rogue drones using an upgraded version of the company's Multi spectral Targeting System, an electro optical/infrared sensor. As part of a year-long Air Force experiment to train operators and evaluate the system's performance in realistic settings, the technology will soon be deployed overseas. The high energy laser system, which is essentially a "anti-drone buggy," is installed on a tiny all-terrain vehicle and uses electro-optical/infrared sensors and High Power Microwave (HPM) devices to identify, track, and interfere with the drones' navigation systems. The UAV is promptly neutralised with a laser after being located.

7. **ATHENA**. The Advanced Test High Energy Asset system, or ATHENA, is a high energy laser system that Lockheed Martin is also developing. The ATHENA is a transportable ground-based system that employs a 30 kilowatt spectral beam combining fibre laser from the Accelerated Laser Demonstration Initiative (ALADIN), which combines multiple fibre laser modules to create a single, potent, high-quality beam that can be used to destroy small UAVs.

8. **IM-SHORAD**. The US Army published an RFI in February 2019 to see if any sources are interested in and capable of delivering 144 IM-SHORAD systems beginning in 2020 and continuing through 2024. The IM-SHORAD system provides 360-degree air defence protection of the Stryker and Armour Brigade Combat Teams (BCT) across the spectrum of military operations using both kinetic and non-kinetic capabilities. The US Army is currently anticipating receiving 36 Stryker-based air defence systems in 2021, followed by 36–72 units annually in 2022 and 2023. In August 2019, the US Army awarded contracts to both Northrop Grumman and Raytheon to build a 50-kilowatt class laser weapon for their fleet of Strykers.

9. **High Power Microwave System**. The USAF is currently developing the Tactical High power Microwave Operational Responder (THOR), a new $15 million Counter UAS technology intended to destroy adversarial tiny UAVs at the speed of light, in collaboration with Verus Research and BAE Systems. In essence, this non-kinetic counter drone weapon would employ a brief microwave pulse to damage the drone's electronics. Additionally, THOR, which the USAF intends to utilise for base defence, offers 360-degree protection and has the ability to shoot down up to 50 drones at once, from any angle. The 20-foot system, which is built for quick deployment, can also be disassembled and flown as cargo on a C-130 Hercules or other aircraft. Built on an expedited, 18-month timeline, the THOR is currently undergoing testing. The system was developed by the Air Force Research Laboratory (AFRL) at Kirtland AF Base, New Mexico. THOR is suitable for relatively short ranges, but the AFRL is working on another system called Counter Electronic High Power Microwave Extended Range Air (CHIMERA) Base Air Defence that is capable of targeting multiple drones at mid- to-long range. CHIMERA is projected to be finished for field testing by 2020. The AFRL is investing $16 million in further field assessment of Raytheon's PHASER High Power Microwave System. The effectiveness of PHASER against drones has already been demonstrated at the Army MFIX exercises in 2018, when the system eliminated 33 drones, two to three at a time.

10. **Drone Swarm**. Another useful counter-UAS tool that drone swarm technology has the potential to be is. In order to improve their air defence capabilities, the US is also working into drones that can kill other drones. The DoD has apparently already invested in two such systems as of the autumn of 2019: Coyote from Raytheon and Interceptor from Anduril Industries. Both are miniature unmanned aerial vehicles (UAVs) that can detect, track, and intercept targets using onboard electro-optical and infrared sensors. Raytheon recently announced a counter drone system called 'Howler,' which uses tube launched Coyotes linked with a truck-mounted radar called Ku Band Radio Frequency System (KuRFS). The Defence Advanced Research Projects Agency (DARPA) is also currently experimenting with using a swarm of autonomous drones and ground robots to assist with military missions through their Offensive Swarm Enabled Tactics (OFFSET) programme. drones from carrying drugs and weapons along the Southern border as drones are being used by the cartel to transport illegal contraband and help migrants illegally cross the border.

THE FUTURE OF ELECTRO MAGNETIC SPECTRUM OPERATIONS (EMSO): EMERGING TECHNOLOGIES AND TECHNIQUES FOR THE INDIAN ARMY

COMPILED BY

LT COL KARTIK BISHT, DSTSC-05 (ARMY)

INTRODUCTION

1. Electromagnetic Spectrum Operations (EMSO) have become an integral component of modern warfare, providing several capabilities that enhance military effectiveness. As technology continues to evolve rapidly, new emerging technologies and techniques in EMSO are expected to further transform modern warfare. This article explores the future of EMSO for the Indian Army, examining emerging technologies and techniques that can enhance military capabilities.

EMERGING TECHNOLOGIES AND TECHNIQUES IN EMSO

2. **5G Technology**. 5G technology promises to revolutionize communication and networking capabilities, providing higher bandwidths, lower latencies, and increased reliability. The Indian Army can leverage this technology to enhance communication capabilities, enabling more effective coordination between various units.

3. **Directed Energy Weapons (DEW).** DEWs utilize concentrated beams of electromagnetic energy to engage and neutralize enemy assets. DEWs can provide an alternative to traditional kinetic weapons, offering more precise and effective targeting capabilities. The Indian Army is actively exploring the use of DEWs to enhance military capabilities.

4. **Quantum Computing**. Quantum computing promises to provide significant improvements in computational power, enabling faster processing of vast amounts of data. The Indian Army can leverage quantum computing to enhance intelligence gathering capabilities, enabling more efficient processing of signals intelligence and other data sources.

5. **Artificial Intelligence (AI).** AI can enhance several EMSO applications, including intelligence gathering, electronic warfare, and cybersecurity. AI can provide real-time analysis of vast amounts of data, enabling more effective decision-making and response to evolving threats.

6. **Blockchain Technology**. Blockchain technology can enhance cybersecurity measures, providing a decentralized and secure platform for data storage and transmission. The Indian Army can leverage blockchain technology to enhance cybersecurity measures and protect against cyber threats.

OPPORTUNITIES FOR THE INDIAN ARMY

7. The emerging technologies and techniques in EMSO provide several opportunities for the Indian Army, including: -

(a) Enhanced Intelligence Gathering. Emerging technologies, such as quantum computing and AI, can provide faster and more efficient processing of signals intelligence and other data sources, enabling more effective intelligence gathering capabilities.

(b) Precise Targeting. Directed Energy Weapons can offer more precise and effective targeting capabilities, reducing collateral damage and minimizing civilian casualties.

(c) Improved Communication. 5G technology can provide higher bandwidths and lower latencies, enabling more reliable and secure communication between various units.

CHALLENGES AND RISKS

8. Despite benefits of emerging technologies and techniques in EMSO, several challenges and risks must be addressed to effectively utilize these capabilities. They include: -

(a) Technological Challenges. Emerging technologies are highly complex, requiring specialized knowledge and skills to operate and maintain. The Indian Army must invest in training and education programs to ensure personnel can effectively utilize these capabilities.

(b) Cost. Emerging technologies can be costly to acquire and maintain. The Indian Army must prioritize investments in emerging technologies based on their potential to enhance military capabilities.

(c) Interference. The use of emerging technologies can result in interference with other electromagnetic devices, such as civilian communication systems.

(d) Vulnerability. The reliance on emerging technologies for critical military operations can make the Armed Forces vulnerable to cyber threats and electronic attacks.

CONCLUSION

9. The future of EMSO is promising, with emerging technologies and techniques offering several opportunities for the Indian Army to enhance military capabilities. The Indian Army must continue to invest in EMSO technologies and techniques, ensuring that personnel are adequately trained and equipped to effectively utilize these capabilities. The challenges and risks must be addressed to effectively utilize these emerging technologies, enabling the Indian Army to maintain its edge in modern warfare.

HOW MASSIVE MIMO HAS REVOLUTIONIZED WIRELESS COMMUNICATION

COMPILED BY

WG CDR RAKESH KUMAR, DSTSC-05 (AF)

1. MIMO stands for Multiple-input multiple-output. While it involves multiple technologies, MIMO can essentially be boiled down to this single principle: a wireless network that allows the transmitting and receiving of more than one data signal simultaneously over the same radio channel. Standard MIMO networks tend to use two or four antennas. Massive MIMO, on the other hand, is a MIMO system with an especially high number of antennas. There is no set figure for what constitutes a Massive MIMO set-up, but the description tends to be applied to systems with tens or even hundreds of antennas. For example, Huawei, ZTE, and Facebook have demonstrated Massive MIMO systems with as many as 96 to 128 antennas.

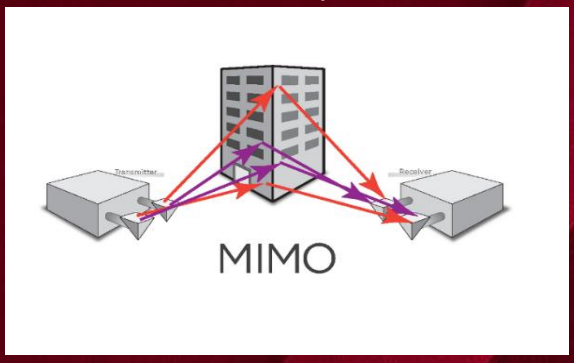
2. The advantage of a MIMO network over a regular one is that it can multiply the capacity of a wireless connection without requiring more spectrums. Reports point to considerable capacity improvements and could potentially yield as much as a 50-fold increase in future. The more antennas the transmitter/receiver is equipped with, the more the possible signal paths and the better the performance in terms of data rate and link reliability. A Massive MIMO network will also be more responsive to devices transmitting in higher frequency bands, which will improve coverage. In particular, this will have considerable benefits for obtaining a strong signal indoors.

3. The greater number of antennas in a Massive MIMO network will also make it far more resistant to interference and intentional jamming than current systems that only utilize a handful of antennas. It should be noted, too, that Massive MIMO networks will utilize beam forming technology, enabling the targeted use of spectrum. Current mobile networks result in a performance bottleneck in densely populated area. With Massive MIMO and beamforming such a process is handled far more smartly and efficiently, so data speeds and latency will be far more uniform across the network. While standard MIMO principles are already in use across multiple Wi-Fi and 4G standards, Massive MIMO will really come into play once 5G is implemented all around. Indeed, it's widely expected that Massive MIMO will be a key enabler and foundational component of 5G.

4. Massive MIMO's ability to serve multiple users - and multiple devices - simultaneously within a condensed area while maintaining fast data rates and consistent performance makes it the perfect technology to address the needs of the forthcoming 5G era. Multiple Input-Multiple Output (MIMO) systems have turn out to be necessity of wireless communication systems to conquer bandwidth restrictions.

ADVANTAGES

5. The key benefit is the efficient separation of the channels for multiple accesses, which reduces the complexity of the cyclic prefix when aligning to face the fading of the channel in several routes. However, performance is only achieved when the orthogonality is maintained between the subcarriers and synchronized correctly. Massive MIMO is an exciting field of 5G wireless research. It promises significant benefits for next-generation wireless data networks, which allow them to accommodate more users with higher data rates, higher reliability, and lower power consumption. The following are the potentials of Massive MIMO: -



(a) **Spectral Efficiency**. By focusing narrow beams of light toward a user, massive MIMO provides higher spectral efficiency.

(b) **Energy Efficiency**. Massive MIMO systems reduce energy consumption by focusing antenna array onto a small section, thus requiring less energy radiated.

(c) **High Data Rate**. Massive MIMO provides greater gain and multiplexing capacity to wireless systems, resulting in higher data rates and greater capacity.

(d) **User Tracking**. Massive MIMO makes tracking users more reliable and accurate by using narrow signal beams.

(e) **Low Power Consumption**. In massive MIMO, linear amplifiers are used to reduce the need for bulky electronic equipment. Therefore, there is a considerable reduction in power consumption.

(f) **Less Fading**. Massive MIMO is robust against fading due to a large number of antennas at the receiver.

(g) **Low Latency**. The latency on the air interface is reduced by massive MIMO.

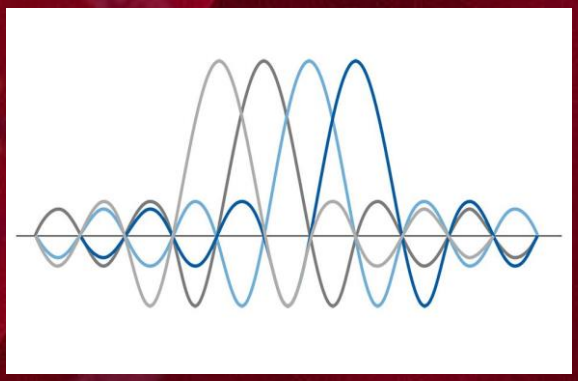
(h) **Reliability**. When MIMO uses multiple antennas simultaneously, it provides more diversity gain, increasing the reliability.

(j) **Enhanced Security**. Physical security is enhanced by massive MIMO's orthogonal channels and narrow beams.

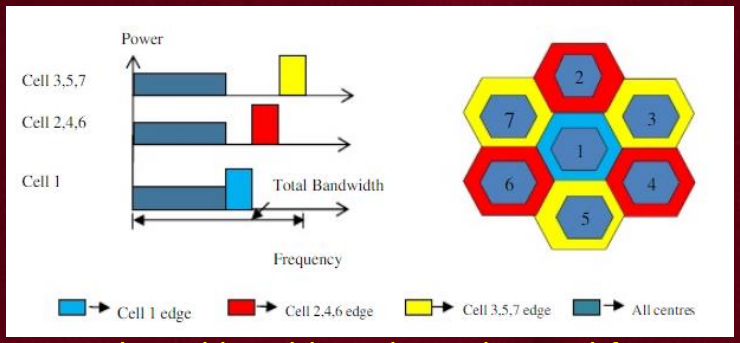
(k) **Low Complex Linear Processing**. The simple signal detectors and precoders are more efficient when there is a greater number of antennas on the base station.

6. **Beam Forming**. In general, beamforming is a particular processing technique for signals that allow for directional transmission or reception. 5G beamforming allows 5G connections more focused toward a receiving device. For example, a typical 5G small cell that does not employ beamforming during its multiple-input multiple-output (MIMO) transmission will not be able to narrowly concentrate or focus its transmit beams to a particular area. With beamforming, the small cell can focus the transmission in a particular direction towards a mobile device such as a cell phone, laptop, autonomous car or IoT node. This improves the efficiency overall of the network and saves energy. If we have more directional beams, it will provide stronger coverage. This means if data is sent on these beams, then the user will be able to get better SINR which will result in higher MCS and consequently better throughput. It will also increase the traffic cell edge as the users will be getting better data rates, even in lower coverage conditions.

7. **OFDM**. *Orthogonal frequency-division multiplexing has become the standard modulation format for 5G New Radio.* Orthogonal Frequency Division Multiplexing (OFDM) is an efficient modulation format used in modern wireless communication systems including 5G. OFDM combines the benefits of Quadrature Amplitude Modulation and Frequency Division Multiplexing to produce a high-data-rate communication system. QAM refers to a variety of specific modulation types like BPSK, QPSK,16QAM (16-state QAM), 64QAM (64-state QAM), etc. OFDM is simply the idea that multiple communication channels can coexist by designating a slice of frequency spectrum for each channel. FDM frequency allocations must not overlap and often have guard bands between the channels to minimize adjacent channel interference.



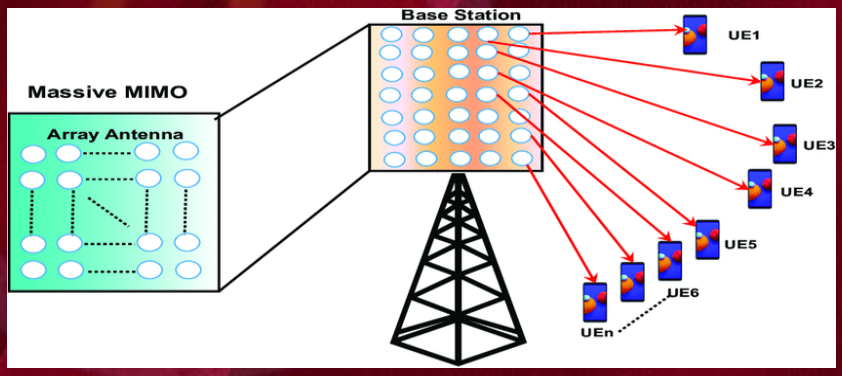
8. **Frequency Reuse**. Technique for using a specified range of frequencies more than once in the same radio system so that the total capacity of the system is increased without increasing its allocated bandwidth. Frequency reuse schemes require sufficient isolation among the signals that use the same frequencies so that mutual interference among them is controlled at an acceptable level. For 5G, frequency reuse can be achieved by using orthogonal frequency division multiplexing to serve separate, non-overlapping geographic regions.



.

9. Future wireless communication will rely on massive MIMO technology. Wireless communication systems can be significantly improved in terms of channel capacity, energy efficiency, and spectrum utilization. Wireless data traffic is likely to surge exponentially, creating a need for more capacity in the cellular spectrum. Large scale MIMO technology provides a solution for this growing global need for mobile data provision. The spectral and energy efficiency is achieved through the use of multiple antennas at both the transmitter and the receiver. Massive MIMO technology is currently less studied, despite the worldwide need for efficient spectrum. This emerging wireless access technology faces a number of open challenges. MIMO has been in use for wireless communications for many years, Massive MIMO will help enhance 5G's ability to scale. Massive MIMO provides huge amounts of antennas at the 5G base station that enhances overall connectivity and provides better speeds. MIMO requires particular algorithms that tell the data where to focus energy. "Massive" in massive MIMO refers to the number of antennas, helping to improve throughput and efficiency of the data. Beamforming, OFDM, frequency Reuse are the foundational technology that works hand in glove with massive MIMO to direct beams of transmission data both horizontally and vertically toward user devices.

10. Multiple Input-Multiple Output (MIMO) systems have turn out to be necessity of wireless communication systems to conquer bandwidth restrictions. Massive-MIMO systems are capable of improving the channel capability of the system. This seminar will present design architecture, challenges, limitations and the possible improvements in a Massive-MIMO system. Findings: It is observed that multiple antenna systems with huge amount of antenna elements at base station are competent to increase data rate by many folds, without requirement of any extra bandwidth, as compared to other existing technologies. Massive-MIMO combined with multiple carrier systems (Massive-MIMO-OFDM) followed by suitable signal detection schemes, like beam forming, gives overwhelming results. Application: With possibilities of further research and continuous improvements, Massive-MIMO system is one of the best suitable choices, among various technologies, for next generation wireless communication systems, like 5G.



ARMORED BULLDOZER: THE NEXT GENERATION ENGINEER PLANT

COMPILED BY

MAJ AMIT KUMAR, DSTSC – 05 (ARMY)

INTRODUCTION

1. A military engineering vehicle is a vehicle built for the construction work or for the transportation of combat engineers on the battlefield. These vehicles may be modified civilian equipment or purpose-built military vehicles. The armoured bulldozer is a basic tool of combat engineering. These combat engineering vehicles combine the earth moving capabilities of the bulldozer with armour which protects the vehicle and its operator in or near combat. Most are civilian bulldozers modified by addition of vehicle armour/military equipment, but some are tanks stripped of armament and fitted with a dozer blade.

2. The first armoured bulldozer was developed by the British during World War II. This was a conventional Caterpillar D8 bulldozer fitted with armour to protect the driver and the engine. The bulldozer was one of several strange, armoured vehicles that were collectively referred to as "Hobart's Funnies" and were operated by the British 79th Armoured Division in support of armoured assaults. The bulldozers were produced in preparation for the Battle of Normandy with the tasks of clearing the invasion beaches of obstacles and quickly making roads accessible by clearing rubble and filling in bomb craters. As Allied armies advanced through Europe, the armoured bulldozer was found to be too slow—there was a need for well-armoured, obstacle clearing vehicle that was fast enough to keep up with tank formations. This need was met by the Centaur Bulldozer—a Centaur tank with the turret removed and a bulldozer blade fitted. Centaur bulldozers were still in use with the British Army at the time of the Korean War.

3. **IDF Caterpillar D9.** Caterpillar nicknamed Teddy Bear is armoured bulldozer that was modified by the Israel Defense Forces, Israeli Military Industries and Israel Aerospace Industries to increase the survivability of the bulldozer in hostile environments and enable it to withstand heavy attacks, thus making it suitable for military combat engineering use. The IDF Caterpillar D9 is operated by the Israel Defence Forces (IDF) Combat Engineering Corps for combat engineering and counter-terrorism operations. The IDF also developed and installed slat armour add-on to deflect rocket-propelled grenade (RPG) rounds. The IDF also operates armoured remote-controlled D9N bulldozers, often incorrectly referred as "black thunder". The remote-controlled bulldozer is used when there is a great risk for human life, mainly when opening dangerous routes and detonating explosive charge. This type of dozer is used by the US, Israel Defence Forces and Canadian Forces.

RELEVANCE FOR THE INDIAN ARMED FORCES.

4. **Conventional Scenario**. In Conventional operations of war, the armoured bulldozer has an important role to play in both Defense and Attack forms of war. As we all know that the area on the western sector is mostly plains and developed consisting abundant build up areas which will mostly be converted into defended localities during the times of hostilities. It imposes a severe time penalty on our operations to clear each house in the buildup area and is greater threat to our troops while neutralizing such targets. In such scenarios armoured bulldozers can be effectively employed to demolish the buildup areas and thereby saving lots of lives and precious time. During the defensive operations the armoured bulldozers will help in developing new axis of maintenance and improvement of defences.

5. **Counter Insurgency/Counter Terrorism**. In Counter terrorist operations the terrorists hiding and shooting from buildup areas are major cause of casualties to our forces which makes it necessary to undertake house intervention drills to clear the threat endangering the lives of troops. The vehicle can also be used to detonate IEDs and explosives, as well as create access and egress routes for combat troops. The bulldozers can be fitted with disparate features, such as crew-operated machine guns, smoke projectors, or grenade launchers and have been effectively used in counter insurgency by the Israeli forces.

6. Survivability and disaster management. The same dozers can also be used in earthworks during peacetime. It can be effectively used in clearance of road or debris in harsh and challenging conditions. Apart from this they can also be employed in neutralising IEDs and carrying out demining and demolition tasks.

7. Armoured bulldozers have proved to be very effective in reducing the unnecessary casualties by efficiently engaging the enemy or terrorists and as Corps of Engineers it would be another feather in our cap to have such an equipment in our equipment profile. It would provide more versatility to the engineers while operating in the combat. During the preparation to the war in Iraq in 2003 the United States Army purchased several D9 armor kits from the IDF and used them to produce similarly fortified D9s. These have been used to clear destroyed vehicles from roads, dig moats, erect earthen-barriers, and construct field fortifications. D9s have also been used to raze houses which sheltered insurgent snipers. Military reports on the Conflict in Iraq say that the D9s were found very effective and "received highly favorable reviews from all that benefited from their use.

CONCLUSION

8. With all its inherent advantages the armoured bulldozer is surely the next generation engineer equipment that Corps of Engineers can think of adding into their inventory. It adds more versatility to an engineer regiment and makes its task far less hazardous while operating in a hostile environment. For this, the possibility of modifying the existing dozers with the engineer regiments should be exploited to make it more cost effective.

SMART DUST

COMPILED BY

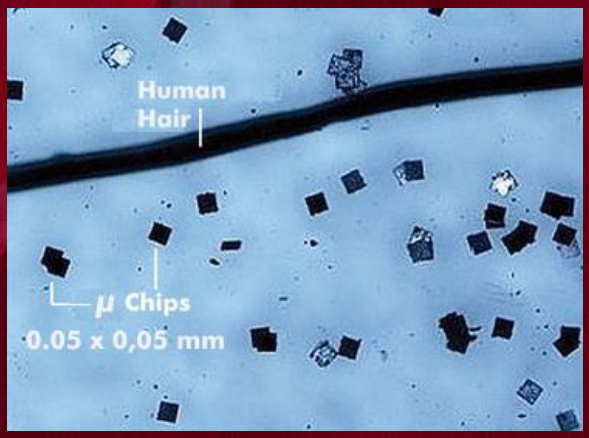
LT COL DIVYAJEET JAMWAL, DSTSC-05 (ARMY)

INTRODUCTION

1. Smart dust refers to wireless networks of sub-millimeter scale autonomous computing and sensing platforms not larger than a grain of sand. The concept of smart dust was first proposed in the late 1990s by researchers at the University of California, Berkeley. The idea was to create a network of tiny sensors that could be deployed in a wide range of environments to collect data on everything from temperature and humidity to chemical and biological pollutants. Smart dust is a vision of the networked future where intelligent networks of trillions of miniscule sensors continuously feel, taste, smell, see, and hear what is going on in their surrounding environment, communicate with each other and exchange information. Smart dust networks are the ultimate Internet-of-Things (IoT) devices. Smart dust is revolutionary because the sensors are small enough to be put anywhere, even in narrow and difficult areas. Smart dust is based on microelectromechanical systems, or MEMS.

TECHNOLOGY

2. Smart Dust encompasses nano-structured sensors that can automatically assemble, align, sense, and report about its local environment. With the help of networked, miniature sensors that can gather and send data in real time, mart dust technology is the creation and use of such devices. The data is transferred from mote to mote until it reaches the transmission node. MEMS consist of any combination of mechanical and electrical (components to work as sensors or actuators.

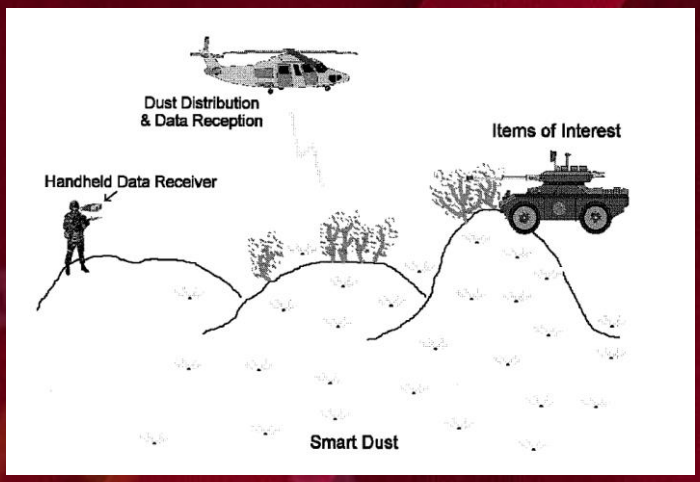


3. Smart dust networks contain nodes that combine sensing, computing, wireless communication capabilities and autonomous power supply in a tiny package with a volume of few cubic millimeters or even less. Smart dust is based on microelectromechanical systems, or MEMS. Very basically, every mote consists of four device classes: sensors, circuits, communication and power supply. The entire package contains one or more MEMS or NEMS sensors to perform the mote's principal sensing purpose of detecting and measuring things like vibration, temperature, pressure, sound, light, magnetic field, etc.

APPLICATIONS

4. **Military**. Smart dust technology in military applications has the potential to improve situational awareness, enhance safety and security, and enable faster and more effective responses to potential threats. However, there are also concerns about the potential ethical and privacy implications of pervasive military surveillance using smart dust technology.

(a) **Surveillance.** Smart dust sensors can be used to monitor enemy movements and detect potential threats. The sensors can be deployed in large numbers over a wide area, providing real-time data to military commanders.



(b) **Intelligence Gathering**. Smart dust sensors can be used to collect intelligence on enemy activity, such as troop movements or weapon deployment. The data collected can be used to inform military strategy and decision-making.

(c) **Battlefield Monitoring**. Smart dust sensors can be used to monitor conditions on the battlefield, such as temperature, humidity, and air pressure. This data can be used to optimize the deployment of troops and equipment.

(d) **Chemical and Biological Detection**. Smart dust sensors can be used to detect chemical and biological agents on the battlefield. This can help to protect troops from exposure to harmful substances and enable faster responses to potential threats.

(e) **Autonomous Systems**. Smart dust sensors can be used to support the development of autonomous military systems, such as unmanned aerial vehicles (UAVs) or ground vehicles. The sensors can be used to collect data and inform decision-making by these systems.

OTHER APPLICATIONS

5. The potential applications of smart dust are vast and varied, and the technology is still in its early stages of development. As smart dust sensors become smaller, cheaper, and more energy-efficient, they are likely to become even more pervasive and impactful in the years to come. Few of them listed as under: -

(a) **Industrial Process Control**. Smart dust sensors can be used to monitor and control manufacturing processes in real-time, helping to optimize production and reduce waste.

(b) **Agriculture**. Smart dust sensors can be used to monitor soil moisture, nutrient levels, and other environmental factors that impact crop growth. This data can be used to improve crop yields and reduce water usage.

(c) **Healthcare**. Smart dust sensors can be used to monitor vital signs, track medication adherence, and detect early signs of disease. This data can be used to improve patient outcomes and reduce healthcare costs.

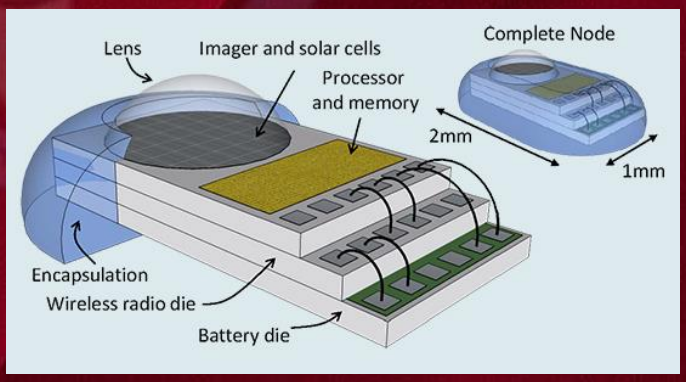
(d) **Smart Cities**. Smart dust sensors can be deployed throughout a city to monitor traffic patterns, air quality, and other environmental factors. This data can be used to improve city planning and reduce congestion and pollution.

(e) **Virtual Keyboard**. A mote can be glued to each of the fingertips. This along with the MEMS augmented-reality heads-up display, your entire computer I/O would be invisible to everyone around you.

FUTURE TRENDS

6. Predicting future trends in smart dust technology is challenging, but there are several potential directions that its development could take as listed as under:-

(a) **Increased Miniaturization**. Future smart dust devices could become even smaller and more energy-efficient, enabling them to be deployed in even greater numbers and in more diverse applications.



(b) **Energy Harvesting**. Smart dust devices might be able to run for longer periods of time without requiring recharging or new batteries due to energy collecting strategies like harnessing solar power or piezoelectric materials to transform mechanical energy into electricity.

(c) **Artificial Intelligence**. As AI and machine learning become more advanced, they could be used to analyse the data collected by smart dust sensors in real-time.

(d) **Wireless Communication**. Future smart dust devices could be designed to communicate wirelessly with each other and with other devices, enabling more complex and interconnected applications.

(e) **Biodegradable Materials**. The development of biodegradable smart dust devices could enable them to be used in applications where they are not easily retrievable, such as environmental monitoring or agriculture. Once they have served their purpose, they would naturally decompose without leaving behind any harmful waste.

(f) **Advanced Sensing Capabilities**. Future smart dust sensors could be designed to detect a wider range of environmental conditions, such as sound, light, or electromagnetic radiation. This could enable more diverse and sophisticated applications in fields such as security, healthcare, and industry.

CONCLUSION

7. Several aspects of our existence, including environmental monitoring, agriculture, healthcare, and industrial process management, could be revolutionised by smart dust technology. Smart dust could help us make decisions more quickly and effectively by using tiny, networked sensors that can gather and analyse data in real-time. This would improve our understanding of and ability to govern the environment around us. Although smart dust is still in its early phases of research, numerous intriguing applications are already being investigated. Some of them include the real-time surveillance of disease outbreaks and the detection of pollutants in the air and water. Others involve optimising crop yields by tracking soil moisture and temperature. There are numerous potential routes that smart dust technology could go in the future. They include enhancing energy efficiency and miniaturisation, creating novel materials that are biodegradable or eco-friendly, and incorporating more sophisticated sensors and artificial intelligence.

EMPLOYMENT OF DRONES AT TACTICAL AND OPERATIONAL LEVEL INCLUDING COUNTER DRONE MEASURES

COMPILED BY

MAJ SUMIT, DSTSC-05 (ARMY)

INTRODUCTION

1. Drones have assumed a leading role in Counter Terrorism and Counter Insurgency and are projected to be of growing importance in future military operations. Their low cost makes them expendable and ideal for highly dangerous or politically sensitive missions. However, technical limitations as well as likely improvements in competing technologies, notably air defence systems, shall circumscribe the military role of drones. Although, an integral part of future warfare, they are unlikely to fully replace manned aircraft and will instead, complement them.

2. Drones are defined as an aircraft that can operate autonomously or can be operated remotely without a pilot on board.

CLASSIFICATION

3. As per The Drone Rules, 2021, drones can be classified as per weight as follows: -

(a)	Nano	-	Less than or equal to 250 grams.
(b)	Micro	-	250 grams to 2 Kg.
(c)	Small	-	2 Kg to 25 Kg.
(d)	Medium	-	25 Kg to 150 Kg.
(e)	Large	-	More than 150 Kg.

EMPLOYMENT AT TACTICAL & OPERATIONAL LEVEL

4. **Offensive Operations**. During offensive operations there are numerous employments for drones, which are enlisted below: -

(a) Intelligence, Surveillance and Recce (ISR).
(b) Information Ops.
(c) Logistic support using Logistic Drones.
(d) Target enemy's Gun Areas and other VAs /VPs.
(e) Details of enemy's minefields.

5. **Defensive Operations**. The drones can be applied in Defensive Operations as under: -

(a) ISR of border areas.

(b) Degradation tasks.

(c) Post Strike Damage Assessment (PSDA).

(d) Delivery of logistics at Isolated localities.

(e) Jamming and Electronic Warfare.

(f) Counter Attack at post captured by enemy.

6. **Counter Terrorism / Counter Insurgency Operations**. The employment of drones in Counter Terrorism / Counter Insurgency Operations is as under: -

(a) Surveillance of Line of Control (LC) & ISR tasks.

(b) Raid on terrorist hideouts.

(c) Area Familiarisation / Area Domination.

(d) Handling of mob including stone pelters.

(e) Road Opening Parties (ROP) duties.

(f) Conduct of Anti BAT (Border Action Team) actions.

(g) Cordon and Search Operations (CASO) / Search and Destroy Missions (SADO).

(h) Intelligence generation.

COUNTER DRONE MEASURES

7. Counter Drone Systems also called as Anti Drone Systems can be passive or active depending upon the sensors and can perform several functions such as: -

(a) Detection.

(b) Identification and Classification

(c) Locating and Tracking

(d) Generate alert and / or trigger a jamming system.

8. There are several technologies that help to detect a drone and based on its distance, altitude, type and various other specifications. The most common being radars, optical sensors and acoustic sensors. Apart from detecting drones they also detect kites, birds and anything that is flying in the air.

9. **Radio Frequency Analysers**. Almost all drones use radio signals for communication, command and control. These Radio frequency sub - systems are designed to detect radio communication between drone and its ground controller. Some RF analysers can even identify the make and model by analysing radio waveform and can even identify the mac address of the drone and the controller.

10. **Radars**. It is a popular technology for detection of drones using 2 dimensional as well as 3 dimensional radars. The difference between both being that 2 D radar can detect all drones but cannot provide information about altitude of the drone which a 3 D radar can do.

11. **Visual Sensors & Image Processing**. The electro optical sensor cameras combined with Artificial Intelligence based image processing software enables the visual detection and description of drones. The EO sensor can cover a field of view from 30 to 360 degrees.

12. **Acoustic Sensors**. They are a microphone or an array of microphones which detect the sound made by drones and calculates its direction. These sensors can be used wherever line of sight of radars is obstructed. They are most economical method of countering drones.

CONCLUSION

13. Drones are not the technology of tomorrow they are the technology of today. On a development scale, they are akin to aircraft in 1939. No longer a wonder, capable of changing the battle but only with asymmetry in battle winning. Tactical drones offer an opportunity to create such a favourable asymmetry. The advantages they accrue for tactical commanders are disproportionate to any other single system or the cost involved. Simultaneously, anti-drone measures and drills needs to be introduced, practices and followed to deny these advantages to the adversaries.

NUCLEAR WPNS UNDER INTERNATIONAL LAW: AN OVERVIEW

COMPILED BY

MAJ PRAKASH RAIKWAR, DSTSC-05 (ARMY)

1. In this introductory sec the types of nuclear weapons that exist or which could be developed are described along with details of their testing and use. It reviews their use under international law, both in the conduct of hostilities and as an act without the requisite nexus to a sit of armed conflict. It also considers disarmament law and non-proliferation rules and measures as well as nuclear weapon free zones (which cover most of the southern hemisphere). It assesses the testing, production, and stockpiling of nuclear weapons under international environmental law.

NUCLEAR WEAPONS

2. A nuclear weapon is an explosive device whose destructive force results from either nuclear fission chain reactions or combined nuclear fission and fusion reactions. Nuclear weapons whose explosive force results exclusively from fission reactions are commonly referred to as atomic bombs, while those that derive much or most of their energy in nuclear fusion reactions are termed thermonuclear weapons.

TYPES OF NUCLEAR WEAPONS

3. In fission weapons, a mass of fissile material is turned into a supercritical mass, producing explosion yields ranging from the equivalent of around one to five hundred kilotons of TNT. The detonation of any nuclear weapon is accompanied by a blast of radiation. Fission also produces radioactive debris, more commonly known as fallout. A thermonuclear weapon uses the heat generated by a fission bomb to compress and ignite a nuclear fusion stage. Thermonuclear weapons typically have a far higher explosion yield than do fission weapons, in the range of megatons rather than kilotons. Fusion reactions do not create fission products, but because all thermonuclear weapons contain at least one fission stage, thermonuclear weapons can generate at least as much nuclear fallout as fission-only weapons.

4. A 'neutron, bomb is a thermonuclear weapon that yields a relatively small explosion but a large amt of neutron radiation. A neutron bomb could be used to inflict massive casualty while leaving infrastructure mostly intact and creating a minimal amt of fallout. In contrast, a salted bomb (surrounding a nuclear weapon with, e.g., cobalt-60 or gold- 98) would produce exceptionally large quantities of radioactive contamination.

HISTORY OF NUCLEAR WEAPONS

5. The fear that the Nazis could develop nuclear wpns prompted United States (US) President Theodore Roosevelt to est the Manhattan Project in 1941. The world's first detonation of a nuclear wpn, the result of the Project's work, occurred just before 5.30 am on 16 July 1945 at a site in New Mexico. The first nuclear wpn attk occurred on 6 Aug 1945 over the city of Hiroshima in Japan. 'Little Boy', as the bomb was named, exploded 580 m above the grnd, rendering an explosion yield of some 16 kilotons of TNT. No one knows exactly how many tens of thousands of people were killed in the attk. Three days later the US detonated 'Fat Man', a plutonium bomb with a larger 20-kiloton yield, 610 m above a suburb of Nagasaki, killing some 74,000 people.

6. The sec state after the US, to test a nuclear bomb successfully was Russia, which in 1949 detonated an atomic bomb, made with plutonium as its nuclear material. 'Greenhouse George', a US test fire in Nevada in May 1951, was the first fusion nuclear wpn to be detonated. The largest nuclear explosion ever is believed to be Russian in origin: its exp yield amounted to 50 megatons. The largest US nuclear detonation, equivalent to 15 megatons, occurred on Bikini Atoll in May 1954. Other nuclear wpn states are India, Israel, and Pakistan as well as the Democratic People's Republic of Korea (DPR Korea) which conducted an underground test of a low-yield nuclear device in October 2006.

USE OF NUCLEAR WEAPONS UNDER INTERNATIONAL LAW

7. Any future use of a nuclear wpn, should one occur, is likely to be in the conduct of hostilities within an international armed conflict. Accordingly, any such use of a nuclear wpn would be judged under the applicable international laws, *jus ad bellum* (international law governing the interstate use of force) and *jus in bello* (international law applicable in armed conflict).

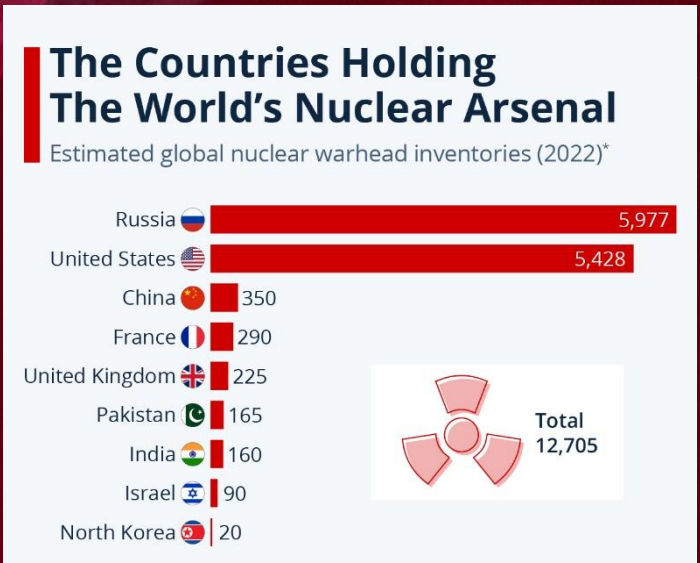
8. **In the Conduct of Hostilities**. The primary rules under *jus in bello* are found in the law of armed conflict, which today is widely termed international humanitarian law (IHL). Under IHL, while states 'do not have unlimited freedom of choice of means in the weapons they use', there is no requirement that each weapon be specifically 'authorized' for its use to be lawful; use of any given weapon will only be unlawful when, and to the extent that, it is prohibited by an applicable conventional or customary rule. A fundamental rule of IHL stipulates that parties to a conflict must direct attacks only against lawful mil objectives. The rule of distinction in attack is a norm of customary international law, applicable in non-international armed conflicts as it is in international armed conflicts.

9. A supporting rule, that of proportionality in attacks, holds that even if an attack is effectively directed against military objective, civilian it must not be launched if it may be expected to be excessive when compared with the direct and concrete mil advantage anticipated.

10. Arguably, environmental damage must also be assessed as part of the proportionality rule. In his separate opinion in relation to the International Court of Justice (ICJ)'s *1996 Advisory Opinion on the Legality of the Threat or Use of nuclear weapons* (the nuclear weapons Advisory Opinion), Judge Schwebel speculated on different types of uses of nuclear weapons and which of these might be lawful or not. He referred to the regularly projected scenario of use of tac nuclear weapons against submarines that are themselves equipped with nuclear weapons as 'discrete mil or nav targets so situated that substantial civilian casualty would not ensue'. Citing the example of use of a nuclear 'depth-charge' to destroy a submarine about to fire nuclear msl (or which has already fired one or more nuclear msl) he concludes this 'might well be lawful'. Indeed, an argument can be made that in such a sit use of a nuclear weapon might not violate IHL.

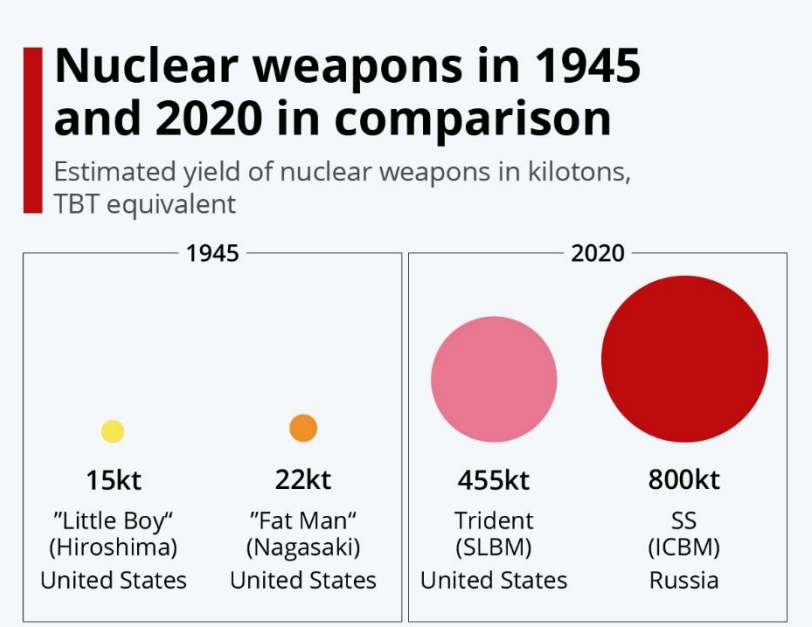
11. A sec often cited scenario, concerns use of a nuclear weapon to destroy an en army situated in a desert. Judge Schwebel concluded, justly, that in 'certain circumstances, such a use of nuclear weapons might meet the tests of discrimination and proportionality; in others not.' But this scenario also evokes another general rule of IHL, namely the prohibition of the use of means and methods of warfare of a nature to cause superfluous injury or unnecessary suffering (the unnecessary suffering rule). This prohibition is one of the very scarce IHL rules designed to protect combatants while they are participating directly in hostilities. The explosion of a nuclear weapon creates phenomenal quantities of heat upon detonation: between 60 and 100 million deg centigrade.

12. Anyone within a radius of 2.5 km from grnd zero and who is unprotected will receive third-deg (full thickness) burns, which will almost certainly be fatal. What is unique about nuclear weapons is the radiation, which occurs at different times. 'Prompt' radiation comes first, soon after the explosion, consisting of neutrons, gamma rays, and electrons. Neutron radiation is an especially hazardous form of radiation to humans. In the explosion of a nuclear wpn, the fireball rises, sucking the cooler air below as well as radioactive debris up from the ground. Water drops are extracted from the cooler air to form clouds. Fallout begins one to two hours afterwards and lasts for a day or so.

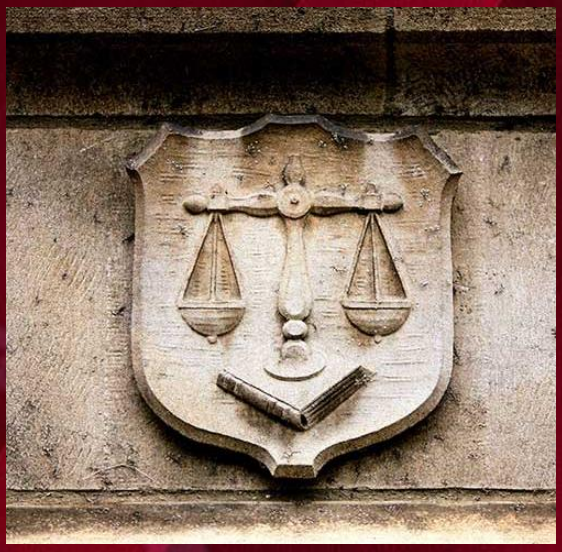


13. The horrific blast and burn injuries nuclear weapons would likely inflict on hundreds of thousands of people across a huge area in the instant detonation are dramatically enhanced by the lethal doses of radiation that would kill in the ensuing days and weeks. But the long-term impact of nuclear weapons also means a significantly increase the risk of cancer mortality throughout the life of the survivors. How the temporal aspect of the unnecessary suffering rule, namely the fact that injury or suffering does not manifest itself immediately, is to be understood, requires further analysis. That said, given the characteristics that would ordinarily manifest themselves from exposure to radiation, it is fair to contend that this issue must be taken into acct in applying the rule. It is extremely hard to envisage a sit where mil considerations would dictate the necessity of recourse to nuclear weapons and that could justify their use against combatants, given the humanitarian effects. A third scenario in which use of nuclear wpns has been claimed to be lawful is as a belligerent reprisal. The term reprisal describes an act that would normally be unlawful under IHL, but which is not prohibited in so far as it seeks to cause an opposing party to the conflict to cease the commission of acts that violate IHL.

14. Many objects and persons enjoy special protection against reprisals. The 1977 Additional Protocol I, which applies to international armed conflicts, stipulates those attacks against the civ population or civilans by way of reprisals are prohibited. A No. of states have protested against this rule. The UK, for instance, when ratifying the Protocol in 1998 attached an understanding whereby if an 'adverse party makes serious and deliberate attacks against the civ population or civilans or against civ objects' the UK would consider itself 'entitled' to take otherwise prohibited measures 'necessary for the sole purpose of compelling the adverse party to cease committing violations but only after formal warning to the adverse party requiring cessation of the violations has been disregarded and then only after a decision taken at the highest level of government.' However, were either the Russian Federation or the US ever to launch a maj strike against the other, owing to the inevitability of the response such a first strike attk would presumably be all-out, with a view to total destruction, or as near to it as could be achieved. The intent of the huge nuclear response that would likely ensue could hardly be claimed to be pursuant to any intent to restore compliance with the law; it would be simple, uncloaked retaliation: collective punishment for as massive a violation of IHL as it is possible to contemplate. Such a nuclear response could thus not be considered a reprisal and, as unfair as it might seem, equally wrong in the eyes of the law.



15. In its nuclear weapons Advisory Opinion, the ICJ concluded that any use of nuclear weapons would 'generally be contrary to the rules of international law applicable in armed conflict, and in particular the principles and rules of humanitarian law'. For any given use of nuclear weapons to satisfy the legal requirements, the circumstances of use would have to be truly exceptional. But such circumstances do exist, notably with respect to low-yield nuclear weapons, and it therefore remains unpersuasive to argue that all nuclear weapons are either inherently indiscriminate or inherently disproportionate under IHL. Arguably, however, IHL in general does not regulate threats, save in a few explicit cases. This question, which seems rather limited in scope and impact, plays a role in the general confusion generated by the ICJ's Advisory Opinion regarding the separation between *jus in bello* and *jus ad bellum*.



16. **Accountability Under International Law**. Given that use of nuclear weapons could constitute violations of IHL rules, such acts would potentially also be subject to rules and proceedings under international criminal law (ICL). This would seem to apply irrespective of the discrepancy between the 1998 Rome Statute of the International Criminal Court (ICC) and other international legal regimes, including customary law, when it comes to specific ref to prohibited weapons. The lack of explicit ICC jurisdiction with regards to nuclear weapon use in the ICC Statute hardly precludes the cat of such use as an international crime under other legal regimes, and subject to national prosecution.

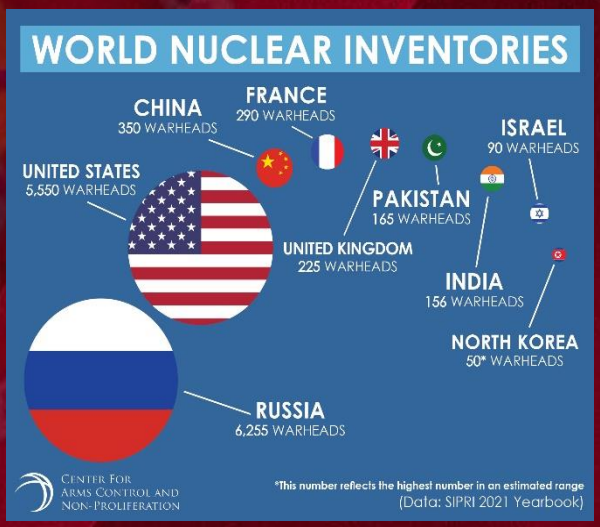
OUTSIDE A SIT OF ARMED CONFLICT

17. The Law outside a situation of armed conflict are as follows.

(a) **Human Rights Law**. In addition to a purely IHL analysis, however, international human rights law is also relevant to a determination of the legality of use of nuclear wpns. In the context of the right to life, international human rights courts primarily analyse whether sufficient effort was made to avoid or limit loss of life in cases where potentially lethal force cannot be avoided. The possible IHL justification that such loss is not excessive compared with the mil advantage expected is not in practice a factor taken into account by such courts. This is imp given the elastic nature that the IHL 'proportionality in attack rule seems to enjoy, and the fact that insufficient precautions in attack are not listed as 'indiscriminate attacks' as such under IHL. Any use of nuclear wpns will, therefore, result in concrete human rights violations that are justifiable, provided that the responsible state has jurisdiction with regard to that use.

(b) It is highly improbable that any use of a nuclear weapon by a state would occur outside an armed conflict, but it is not inconceivable. Potentially, such an act would amount to genocide when 'committed with intent to destroy, in whole or in part, a national, ethnical, racial or religious group, as such'. If it were undertaken as part of a widespread or systematic attack against a civ population where the perpetrator has knowledge of the attack, it could amount to a crime against humanity. According to the International Criminal Tribunal for the former Yugoslavia (ICTY), a widespread attack may be the 'cumulative effect of a series of inhumane acts or the singular effect of an inhumane act of extraordinary magnitude'.

(c) **Non-State Armed Groups**. Arguably more probable is use of a nuclear weapon by a non-state actor as an act of terrorism. The 9/11 Commission Report cited testimony in February 2004 by George Tenet, the Director of the US Central Intelligence Agency (CIA), who warned that al-Qaeda 'continues to pursue its strategic goal of obtaining a nuclear capable. Tenet also asserted that 'more than two dozen other terrorist groups are pursuing CBRN [chemical, biological, radiological and nuclear] materials. Also, according to the 9/11 Commission Report, Khalid Sheikh Mohammed admitted he considered proposing to target a nuclear power plant in the 9/11 attacks and claimed that Mohammed Atta incl a nuclear plant in his preliminary target list, but that Bin Laden decided to drop that idea. The treaty regime prohibiting armed non-state actors' access to nuclear weapons and material is fragmented and often overlapping. As a result of US concern, on 28 April 2004 the United Nations (UN) Security Council, acting under Chapter VII of the Charter, adopted Resolution 1540 without a vote, in which it affirmed that the proliferation of nuclear, chemical, and biological weapons and their means of delivery constitute a threat to international peace and security and obliged all states to: 'refrain from providing any form of support to non-State actors that attempt to develop, acquire, manufacture, possess, transport, transfer or use nuclear, chemical or biological weapons and their means of delivery.'



18. **Use Under 'Jus ad Bellum'**. In parallel, and distinct from, determinations under IHL and human rights law of the legality of any future use of nuclear weapons, if use by a state were to occur on the territory or against the armed forces of another, the requirement of *jus ad bellum* would also need to be satisfied. This body of law, which regulates the interstate use of force, would allow for weapons, potentially including nuclear weapons, to be used in self-defence against an armed attack. To do so, the law would judge the necessity for use of force and whether the force that was actually used was proportionate to the aim of repelling the attack.

19. Necessity *ad bellum* concerns the circumstances in which the state exercising its right of self-defence may lawfully use force, namely that there be no reasonable alternative to using force. This does not appear to require exhaustion of all peaceful measures. In its judgment in the Oil Platforms case, the ICJ seems to have considered necessity *ad bellum* to require the contemporaneous and bona fide belief on the part of the state claiming self-defence that the necessity for its particular action existed. In fact, it is thought highly unlikely that, under modern *jus ad bellum,* absence of such belief conclusively negates necessity claims, nor does its existence conclusively establish necessity. Arguably, however, when an armed attack has not yet occurred imminence (i.e. close temporal proximity between an offending state's future attack and therefore to which the defending state resorts) is an element of necessity *ad bellum.*

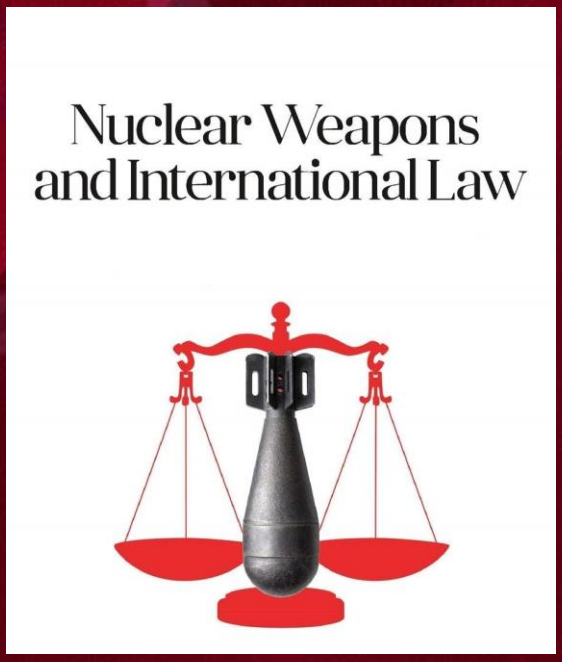
20. With respect to the proportionality calculation, there are two reqmts; first, force used in self-defence should be assessed in light of the fulfilment of defensive purposes, sec, the amt of force used in self-defence should not be obviously excessive; it does not, though, need to be strictly proportionate to the offensive force. Perhaps a surprise to some, the law would not impose particular restrictions on nuclear wpns *as a wpn type,* but merely consider their use as one element in the use of force equations. Arguably, the same formula also applies to threats *ad bellum:* threatening use of force by nuclear wpns is governed by the same legal framework as threats of the use of force in gen. In its Nuclear Wpns Advisory Opinion, the ICJ found, by seven votes to seven, with the president's casting vote, that: 'in view of the current state of international law, and of the elements of fact at its disposal, the Court cannot conclude definitively whether use of nuclear wpns would be lawful or unlawful in an extreme circumstance of self-defence, in which the very survival of a State would be at stake.'

21. This has sometimes been understood to conflate the question of whether the legitimacy of an *ad bellum* cause may justify the use of nuclear weapons in violation of *jus in bello*. The question of whether the separation principle between the two bodies of international law remains valid is central to this assessment. Although debate on the validity of the separation principle is largely doctrinal, it also has imp practical implications, particularly in relation to the use of nuclear weapons. Although state practice in some cases has disregarded the separation principle, this can be considered a departure from treaty and customary international law, as confirmed by international criminal courts and tribunals and the 2001 Articles on the Responsibility of States for Internationally Wrongful Acts.

22. The 'conflationist' position, which seeks to subordinate *jus in bello* to *jus ad bellum,* is based on an incorrect understanding of the law. In practical as well as legal terms, IHL would disintegrate as a result of linking its application to the perceived lawfulness of the *ad bellum* use of force. Moreover, the 'conflationist' view appears to be linked in particular to a flawed understanding of the two aspects of proportionality analysis under each of the two branches of international law. The application of the proportionality principle under *jus ad bellum* is intended to limit the deg of damage that can be inflicted on the enemy to what is proportionate to repelling the attack. Conflating the two proportionality principles in such a manner transforms it from a principle of limitation to one that can be invoked to justify a degree of injury and destruction that would otherwise be considered clearly excessive in the proportionality equation under *jus in bello.* Neither treaty nor customary international law supports such a proposition, which is why the use of nuclear weapons in a manner that violates IHL cannot be considered consistent with international law irrespective of the sit under *jus ad bellum*. The ICJ does, though, appear to have been guilty of 'conflationism' in its statement in the nuclear weapons Advisory Opinion that 'If an envisaged use of weapons would not meet the requirement of humanitarian law, a threat to engage in such use would also be contrary to that law'. This statement seems to be largely without legal support, at least from a *lex lata* point of view. The threat of use of force, prohibited under the UN Charter, has thus been included in the *jus in bello* debate without sufficient legal justification.

CONCLUSION

23. Summing up, it should be noted that there is no unequivocal and explicit rule under international law against use of nuclear weapons, although, in particular, IHL significantly restricts the possibility for lawful use. With regard to possession, production, and stockpiling of nuclear weapons, a number of regimes constitute important regulatory frameworks that to a large degree have prevented nuclear proliferation. In contrast to other legal regimes pertaining to weapons of mass destruction, which have been banned because it is assumed that their use cannot comply with IHL requirements, nuclear weapon use, production, transfer, and possession is not explicitly prohibited. Disarmament obligations on the nuclear weapons states remain contested and remain challenging to enforce.



THE IMPACT OF TECHNOLOGY ON COUNTERTERRORISM OPERATIONS

COMPILED BY

MAJ AKHIL RAJ RV, SC , DSTSC-05 (ARMY)

INTRODUCTION

1. The use of technology has had a profound impact on counterterrorism operations in recent years. From advanced surveillance systems to sophisticated data analysis tools, technology has revolutionized the way that security agencies combat terrorism. This article will explore some of the keyways in which technology is changing the landscape of counterterrorism operations.

ADVANCED SURVEILLANCE SYSTEMS

2. One of the most significant developments in counterterrorism technology is the advancement of surveillance systems. High-tech cameras, drones, and other advanced sensors have greatly improved the ability of security agencies to monitor potential terrorist activity. These systems are often able to operate in remote or difficult-to-reach locations, providing real-time intelligence to law enforcement officials. Additionally, advances in facial recognition technology have made it easier to identify and track individuals suspected of involvement in terrorist activities.

SOCIAL MEDIA ANALYSIS

3. Social media has become a powerful tool for terrorist organizations to communicate, recruit new members, and plan attacks. However, it has also become a valuable source of intelligence for security agencies. Using sophisticated data analysis tools, security agencies can monitor social media activity to detect patterns and identify potential threats. This can include everything from analyzing social media posts for keywords and hashtags associated with terrorism to tracking the location of individuals who are known to be affiliated with terrorist groups.

ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING

4. Artificial intelligence (AI) and machine learning are becoming increasingly important in counterterrorism operations. These technologies can analyze large amounts of data quickly and accurately, making it easier for security agencies to identify potential threats. Machine learning algorithms can be trained to recognize patterns in data that may indicate terrorist activity, and they can be used to predict the likelihood of future attacks. Additionally, AI-powered chatbots can be used to engage with individuals suspected of involvement in terrorism, providing law enforcement officials with valuable intelligence.

CYBER FORENSICS

5. Terrorist organizations are increasingly using the internet to communicate, plan attacks, and raise funds. As a result, cyber analysis and investigation has become an essential component of counterterrorism operations. Security agencies must be able to monitor and intercept online communications and prevent cyberattacks on critical infrastructure. Additionally, cybersecurity experts can use advanced techniques to track the flow of money through online channels, disrupting the funding of terrorist organizations.

VIRTUAL REALITY SIMULATIONS

6. Virtual reality training can help soldiers to better prepare for room intervention drills by simulating realistic scenarios. This technology can help soldiers to develop the necessary skills and strategies to respond effectively in high-pressure situations.

GIS TECHNOLOGY

7. By collecting data on population density, demographics, and other relevant information, security agencies can develop a better understanding of potential terrorist threats and plan operations. This information can then be integrated into a GIS system, which can be used to create a digital map of the area. This map can be used to plan counter terrorist operations on specific int, helping security agencies to allocate resources and develop targeted counterterrorism strategies.

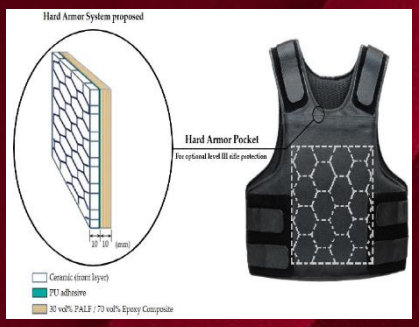
NON-LETHAL CROWD-CONTROL MEASURES

8. One technology that has gained popularity for non-lethal crowd control is acoustic devices. Acoustic devices emit high-pitched sounds that are uncomfortable for humans, making them effective in dispersing crowds. These devices can be mounted on vehicles or used as handheld devices, allowing them to be easily deployed in a variety of situations. The Long-Range Acoustic Device (LRAD) is one example of an acoustic device used for crowd control. It can emit a directional sound beam over a long distance, allowing security personnel to target specific individuals or areas.

9. Another technology used for crowd control is the use of microwave systems. Microwave systems use directed energy to create a sensation of intense heat on the skin, which can cause discomfort and pain, forcing individuals to disperse. The Active Denial System (ADS) is an example of a microwave system used for crowd control. The ADS uses a non-lethal millimeter wave beam to create a sensation of heat on the skin, causing individuals to move away from the source of the beam.

COMPOSITE MATERIALS

10. Bulletproof composite materials are also being developed using new technologies such as carbon nanotubes and graphene. These materials have the potential to provide even greater protection against high-velocity projectiles, while also being lighter and more flexible than traditional bulletproof materials. Another type of bulletproof composite material is made from ceramic plates. These plates are made from materials such as boron carbide or silicon carbide, which are highly resistant to impacts and able to stop high-velocity bullets.



11. Blast-resistant structures are designed to withstand the impact of explosive devices, such as car bombs or improvised explosive devices (IEDs). Advanced composite materials can be used to reinforce the walls, ceilings, and floors of buildings, making them more resistant to blast effects. These materials can also be used to create blast-resistant windows and doors, which can help to contain the force of an explosion and prevent shrapnel from entering the building. Similarly, composite materials can be used to reinforce the hulls of vehicles used in counterterrorism operations, such as armored personnel carriers and mine-resistant ambush-protected vehicles. By reinforcing the vehicle with advanced composite materials, the vehicle can better withstand the impact of explosive devices and protect the occupants inside.

CONCLUSION

12. The impact of technology on counterterrorism operations cannot be overstated. Advanced surveillance systems, social media analysis, artificial intelligence and machine learning, cybersecurity, and biometric technology have all played critical roles in the fight against terrorism. As technology continues to evolve, it is likely that new advancements will be made, further enhancing the effectiveness of counterterrorism operations. However, it is also important to recognize the potential ethical and privacy concerns associated with the use of these technologies, and to ensure that they are used responsibly and with appropriate oversight.

USING BLOCKCHAIN TO IMPROVE WASTE MANAGEMENT IN DEVELOPING COUNTRIES

COMPILED BY

DY COMMANDANT PRAJAKT SHINDE, DSTSC-05 (CG)

INTRODUCTION

1. Waste management is a critical issue in many developing countries around the world. Inadequate waste collection, treatment, and disposal systems can lead to environmental pollution, public health hazards, and the loss of valuable resources. Despite the importance of effective waste management, many developing countries lack the necessary infrastructure and resources to manage waste sustainably.

2. Blockchain technology, which provides a transparent and secure system for tracking and verifying transactions, has the potential to address some of the challenges faced by developing countries in waste management. By creating a secure and traceable record of every step in the waste management supply chain, blockchain can help to improve the efficiency, transparency, and accountability of waste management systems in developing countries.

3. In this article, we will explore how blockchain technology can improve waste management in developing countries, and how it has been used in case studies around the world. We will also discuss the potential benefits and challenges of using blockchain in waste management and call for more research and investment in this promising technology to address the urgent challenge of waste management in developing countries.

CURRENT STATE OF WASTE MANAGEMENT IN DEVELOPING COUNTRIES

4. In many developing countries, waste management systems are inadequate and inefficient, leading to environmental pollution, public health hazards, and the loss of valuable resources. According to the World Bank, over 90% of waste in low-income countries is openly dumped or burned, leading to toxic emissions, soil and water contamination, and the spread of diseases.

5. The lack of infrastructure and resources for waste management is a significant challenge in many developing countries. Many municipalities lack the necessary equipment, personnel, and funding to collect, transport, and dispose of waste properly. This leads to irregular waste collection, overflowing dumpsites, and inadequate treatment facilities.

6. Another challenge in waste management in developing countries is the lack of reliable data on waste generation, collection, and disposal. In many cases, waste is not properly tracked, leading to inefficiencies and potential health and environmental hazards.

7. Moreover, waste management practices in many developing countries are not sustainable. Many waste management systems focus on disposal rather than reducing waste generation, reusing or recycling materials.

8. In summary, the current state of waste management in developing countries is inadequate, inefficient, and unsustainable. Developing countries face significant challenges in waste management due to the lack of infrastructure and resources, unreliable data, and unsustainable practices.

HOW BLOCKCHAIN CAN HELP IMPROVE WASTE MANAGEMENT IN DEVELOPING COUNTRIES

9. **Transparency and Traceability**. Blockchain technology can provide a transparent and secure system for tracking waste from its generation to its disposal. With blockchain, every step in the waste management process can be recorded on a distributed ledger that is visible to all stakeholders in the waste management supply chain. This can help to ensure that waste is being disposed of safely and sustainably, reducing the risk of environmental pollution and public health hazards.

10. **Reliable Data**. Blockchain technology can help to address the lack of reliable data on waste generation, collection, and disposal. With blockchain, all waste-related transactions can be recorded in a tamper-proof ledger, providing reliable and transparent data for waste management stakeholders. This can help to improve waste management planning and decision-making, leading to more effective and efficient waste management systems.

11. **Accountability**. Blockchain technology can help to promote accountability in waste management systems. With blockchain, every stakeholder in the waste management supply chain can be held accountable for their actions. This can help to reduce corruption and fraud in waste management systems, leading to more transparent and efficient waste management practices.

12. **Incentivization**. Blockchain technology can be used to incentivize sustainable waste management practices. For example, waste generators can be rewarded for reducing their waste generation, while waste collectors can be incentivized to collect and dispose of waste in a sustainable manner. This can help to promote sustainable waste management practices, leading to reduced environmental pollution and improved public health.

13. **Efficiency**. Blockchain technology can help to improve the efficiency of waste management systems by reducing the need for intermediaries and streamlining waste-related transactions. This can lead to cost savings and improved waste management practices in developing countries.

CASE STUDIES

14. **Plastic Bank**. Plastic Bank is a blockchain-based social enterprise that aims to reduce ocean plastic pollution by incentivizing waste collectors in developing countries to collect and recycle plastic waste. In Haiti, for example, Plastic Bank has set up collection centers where waste collectors can exchange plastic waste for digital tokens that can be redeemed for cash or other goods and services. The digital tokens are stored on a blockchain, providing a transparent and secure system for tracking plastic waste from its collection to its recycling. This has helped to reduce plastic pollution in the ocean while providing a source of income for waste collectors in Haiti.

15. **Waste Ledger**. Waste Ledger is a blockchain-based waste management platform that aims to improve waste management in developing countries by providing a transparent and efficient system for tracking waste-related transactions. In Nigeria, for example, Waste Ledger has partnered with waste management companies to provide a platform for recording waste generation, collection, transportation, and disposal data on a blockchain. This has helped to improve waste management planning and decision-making in Nigeria, leading to more effective and efficient waste management systems.

16. **RecycleGO**. RecycleGO is a blockchain-based waste management platform that aims to incentivize sustainable waste management practices in developing countries. In Indonesia, for example, RecycleGO has partnered with a waste management company to provide a platform for tracking plastic waste from its collection to its recycling. Waste collectors are incentivized to collect plastic waste by receiving digital tokens that can be redeemed for cash or other goods and services. The digital tokens are stored on a blockchain, providing a transparent and secure system for tracking plastic waste and ensuring that it is recycled sustainably.

17. In summary, these case studies demonstrate how blockchain technology can be used to improve waste management in developing countries by providing transparency, efficiency, and incentivization for sustainable waste management practices. While these case studies are relatively new, they show promising results and suggest that blockchain technology has the potential to revolutionize waste management in developing countries.

BENEFITS

18. **Improved Data Management**. Blockchain technology can help to address the lack of reliable data on waste management in developing countries by providing a secure and efficient system for recording waste-related transactions.

19. **Incentivization for Sustainable Waste Management Practices**. Blockchain technology can incentivize sustainable waste management practices by rewarding waste generators and collectors for reducing waste generation, collecting waste sustainably, and recycling waste.

20. **Streamlined Waste Management Processes**. Blockchain technology can streamline waste management processes by reducing the need for intermediaries and simplifying waste-related transactions.

21. **Potential for Cost Savings**. Blockchain technology can help to reduce costs associated with waste management by improving efficiency and reducing the risk of fraud or corruption.

CHALLENGES

22. **Adoption and Implementation**. The adoption and implementation of blockchain technology can be challenging in developing countries, where there may be limited technical infrastructure and expertise.

23. **Cost**. The cost of implementing blockchain technology can be a barrier to adoption, especially for small and medium-sized waste management companies.

24. **Privacy and Data Protection**. The use of blockchain technology for waste management may raise concerns about privacy and data protection, especially if sensitive data is stored on the blockchain.

25. **Interoperability**. Interoperability between different blockchain platforms and systems can be a challenge, which may limit the effectiveness of blockchain technology for waste management.

CONCLUSION

26. Waste management is a pressing issue in developing countries, and traditional waste management systems have struggled to keep pace with the rapid increase in waste generation. However, blockchain technology offers a promising solution for improving waste management by providing transparency, efficiency and incentivization for sustainable waste management practices.

WRESTING THE POTENTIAL OF GAGAN SBAS FOR IAF & ARMED FORCES AVIATION APPLICATIONS AND BEYOND

COMPILED BY

SQN LDR J SATHISH KUMAR , DSTSC-05 (AF), MILIT

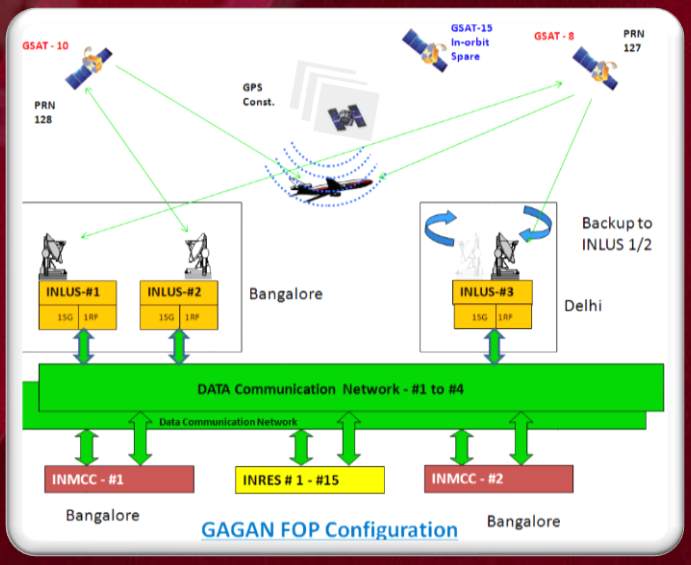
INTRODUCTION

1. GAGAN (GPS Aided GEO Augmented Navigation) is a Satellite Based Augmentation System (SBAS), aimed at augmenting space-based navigation and air traffic management capabilities for all phases of civil aviation flights within the regional coverage of the Indian sub-continent (though it covers well beyond the Indian area of interest, including south and east Asia). The project has been developed and established by the Airports Authority of India (AAI), jointly with ISRO. The space segment has been established by ISRO while the ground segment has been established jointly by ISRO and Raytheon on contract.

2. The project has made India only the fourth entity on the globe, after the United States, EU and Japan to establish a regional SBAS for air navigation. The Indian SBAS bridges the geographic gap between the EGNOS (European Geostationary Navigation Overlay Service) and the Japanese MSAS (MTSAT SBAS) and thus ensures a seamless service for air navigation over a major part of the globe.

SPACE SEGMENT

3. The space segment consists of two main satellites and one in-orbit spare, launched and operated by ISRO. The primary function of the satellites is to be the GAGAN Signal in Space (SIS) elements by carriage of the GAGAN payloads; these payloads trans-receive the GPS augmentation / error correction signals based on ground reference stations - INRESs. GSAT-8 was the first among the constellation of GAGAN satellites. It was launched on 21 May 11 into a Geo-Synchronous Orbit (GSO) and positioned at 55°E longitude. To serve the ever-increasing requirements for Ku / C Band transponders, GSAT-10 was launched on 29 Sep 12 with 12 Ku-Band, 12 C-Band & 12 Ext-C Band transponders and a dedicated GAGAN payload.



GSAT-15 is the in-orbit spare with 24 Ku-Band transponders and the GAGAN payload. It was put on orbit on 10 Nov 15. With the launch of the satellite, the GAGAN space constellation was completed.

GROUND SEGMENT

4. The ground segment consists of 15 Indian Reference Stations (INRESs), 3 Indian Land Uplink Stations (INLUSs) and 2 Indian Master Control Centers (INMCCs), along with the 4 chains of networks (OFC and VSAT) linking the entire segment on ground. The ground stations for the system have been established by Raytheon (the company also developed the US GPS Wide Area Augmentation System (WAAS) & was also engaged with the Japanese MSAS). ISRO has also provided additional ground equipment. The ground segment, together, originate the GPS augmentation signals, transmitted to the receiver end (user segment), through the space segment.

CAPABILITIES & AVIATION APPLICATIONS

5. As conceptualised by AAI, GAGAN is primarily for application in the domain of civil aviation. GAGAN provides civil aviation services from the Navigation and Air Traffic Management viewpoint. It supports flight operations for all phases in flight including Surface, Approach and Terminal phases as well as Oceanic / Trans-Continental. By its design, it lowers the operational minima for terminal phases in airfields / runways not equipped with ILS. It can function as a back up to ILS facilities. It facilitates terminal procedures like curved approaches. Effective flight / traffic management can be ensured by using GAGAN for dynamically managing departure / climb / descent / approach profiles as well as engine performance metrics. Terminal area procedures can be optimised to be more reliable and time / resource saving. The trajectories therein could be designed to be operator preferred.

6. It renders operational nav capability in areas / sectors without adequate nav infrastructure. More efficient routes / procedures can be designed and defined, thereby resulting in fuel savings. This in turn would enable the green initiative by reducing the carbon footprint. It would also make the civil aviation operations more economical and be cost-saving for the economy.GAGAN enables all weather conditions, enhances environmental / obstacle clearances and reduces risk of CFIT. Overall, it enhances the safety factor in aviation.

7. On the aviation front, GAGAN is operational with two kinds / levels of services. It is certified for RNP 0.1 (Required Nav Performance 0.1) over Indian FIR. RNP 0.1 refers to an accuracy of 0.1 nm or 0.1852 Km in the nav services provided. GAGAN also provides APV-I (Approach with Vertical Guidance, Level-I) standard services across majority of Indian mainland. GAGAN provides a SIS accuracy of 3 m (<10 ft), as against the requirement standard of 7.6 m (25 ft).

NON-AVIATION APPLICATIONS

8. GAGAN has multiple applications in the non-Aviation domains as well. GAGAN can be utilised for Nav, Positioning, Timing and Tracking in maritime sector (ships) as well as in transportation sector (both road & rail). It can enhance coastal security as well as road/rail traffic management and public governance. GAGAN Message Service (GMS) is inherent in the GAGAN System. The service can be used for trans-receiving of various information. SAR, Met Broadcasting, Disaster Management Early Warning, Relief / HADR Operations are relevant applications.

MISSILE SYSTEM APPLICATIONS

9. The utilisation of GAGAN (though an intended civil aviation application by design) has been expanded by imagination and innovation. One such fine example is the G3oM (GPS, GLONASS, GAGAN on Module) GNSS receiver designed and developed by the DRDO Lab Research Centre Imarat (RCI) of the Dr.APJ Abdul Kalam Missile Complex at Hyderabad. The miniaturised receiver device has amply illustrated that use of GAGAN is limited only by the innovation of the User segment.

10. RCI has designed the receiver (weighing less than 17 gms), capable of receiving and integrating GNSS signals from GPS, GLONASS and GAGAN. As a result, the receiver provides high accuracy for GNSS based inertial navigation. The receiver has been tested / integrated on the BrahMos Cruise Missile System and paves way for a target hit accuracy of less than 5 m. Coupled with inertial systems, hit accuracy of the G3oM equipped missiles are claimed to be better than seeker-based accuracy.

TAKEAWAYS FOR IAF & ARMED FORCES

11. The GAGAN SBAS for aviation applications isn't a Precision Approach (PA) solution. However, with its APV-LPV approach procedures, the guidance accuracy can be approximated to that of Cat-I ILS approaches. So, GAGAN is an optimal solution for non-ILS military airbases, though it doesn't make much difference to MAFI-equipped bases with ILS systems. With respect to Area Navigation, it provides a good enroute nav solution with its certified RNP 0.1 standard. As compared to the LOS-Range limitations, Terrain / Obstruction constraints of the other Nav systems like VOR, GAGAN SBAS is an alternative solution even for VOR enabled bases.

12. The laggard is the User segment, wherein equipping aviation platforms with GAGAN SBAS receiver has been lacking. The very civil aviation sector, for which the SBAS has been developed for, hasn't seen the complete light of it. Probably, the lag is due to the cost and effort required in modification / equipping aviation platforms. The redundancy as compared to Precision Approach systems like ILS (especially of Cat-III standards) as well as availability of PA / ILS systems in most of the commonly used civil aerodromes are also retarding factors.

13. In stark contrast, military applications would revolve around most remote and regional joint-user aerodromes as well at prepared facilities like ALGs. Other than at fully established airbases, GAGAN would thus be a favourable alternative. So, rather than waiting for the civil sector to stabilise before the military coming onboard, the military aviation platforms should be promptly initiated to be equipped with GAGAN receivers. As well established by the G3oM receiver, indigenous capability exists, that too, within the defence sector. The requirement is a rapid drive to modify and integrate the indigenous receivers with navigation systems of military aircraft. Use of GAGAN has to be envisaged from design and development stages of new military platforms.

14. The next aspect is the accuracy and availability of GPS signals during any conflict that India might be engaged in future. As amply exemplified in the Kargil conflict, the Standard Positioning Services (SPS) signals may be hindered in availability / accuracy. As experienced during recent stand-offs, GPS Jamming has hampered accuracy of signals received by military aircraft close to airbases. GAGAN is a solution for augmenting accuracy for both navigation and targeting.

15. Taking on from the example of BrahMos cruise missiles, all indigenous missile & weapon systems need to be equipped with GAGAN receivers, in addition to GPS & GLONASS. The weapon control systems of ac need to be modified even for guiding imported weapons more accurately using GAGAN. Other than aviation and targeting applications, GAGAN can suitably find use in surface-based receiver applications. SAR, HADR / Relief missions, Disaster Management, Information broadcasting, Met services, maritime / coastal security applications are examples.

CONCLUSION

16. The GAGAN SBAS provides aviation with the four essential elements for Air Nav viz., availability, accuracy, continuity and integrity. It has been primarily designed for civil aviation applications. However, as it can be realised, innovating with the user segment and GNSS receivers can bring about effective applications for GAGAN in armed forces, especially in aviation. Considering the availability of more accurate precision approach systems in most civil aviation airfields, GAGAN finds optimal suitability for the military and its remote airfields / ALGs. Adequate thrust to drive the military aviation and non-aviation user segments is essential to capitalise on the potential offered by the GAGAN SBAS system. In future, integration with the indigenous NavIC GNSS as well interoperability with the GPS & GLONASS systems would make GAGAN a true force multiplier.

SYNTHESIS AND APPLICATION OF CARBON NANOTUBES (CNTs) FOR 5/6TH GENERATION FIGHTER AIRCRAFT STRUCTURES'

COMPILED BY

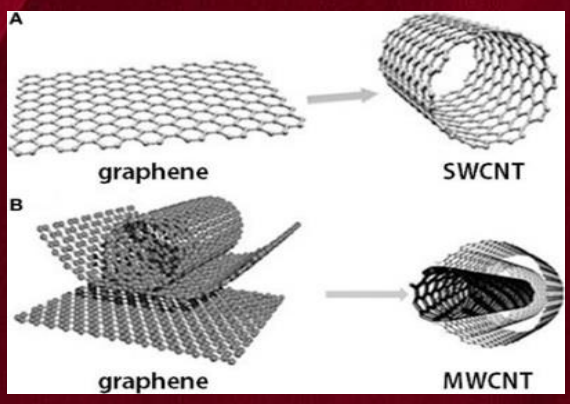
SQN LDR AMAR PANDEY, DSTSC-05(AF)

INTRODUCTION

1. Carbon nanotubes (CNTs) are tubes made of carbon with diameters typically measuredin nanometers. Carbon nanotubes have exceptional tensile strength and impact strength owing to their nanostructure and strength of the bonds between carbon atoms. Many material scientists including those from MIT (USA) and IIT Kharagpur have found ways to bond CNTs and polymer into a composite which is substantially stronger and more resistant to damage than other advanced composites. These results have been published in many renowned journals. These researchers embedded these tiny forests of carbon nanotubes within a glue-like polymer matrix, then pressed the matrix between layersof carbon fiber composites. The nanotubes, resembling tiny, vertically aligned stitches, worked themselves within the crevices of each composite layer, serving as a scaffold to hold the layers together. In experiments to test the material's strength, a US team found that compared to existing composite materials, the stitched composite was 30 percent stronger, with standing greater forces before breaking apart. As per these studies, the improvement may lead to stronger, lairplane parts. One such research is already in a mature stage at Swedish aerospace and defense company Saab AB. DRDO also synthesizes CNTs in its lab. CNTs can be produced very easily in lab through chemical vapour deposition (CVD) without requiring any expensive apparatus. Further by electrospinning, composite made of (CNT and a suitable polymer) can be easily synthesized. Such composites are slated to find their applications in airframe, wiring, canopy, avionics etc of 5th & 6th generation fighter aircraft. Apart from aerospace, CNT based products are already topping the charts in the most advanced applications such as medical, instrumentation, electronics etc.

SYNTHESIS OF CNT AND COMPOSITE OF (CNT-POLYMER)

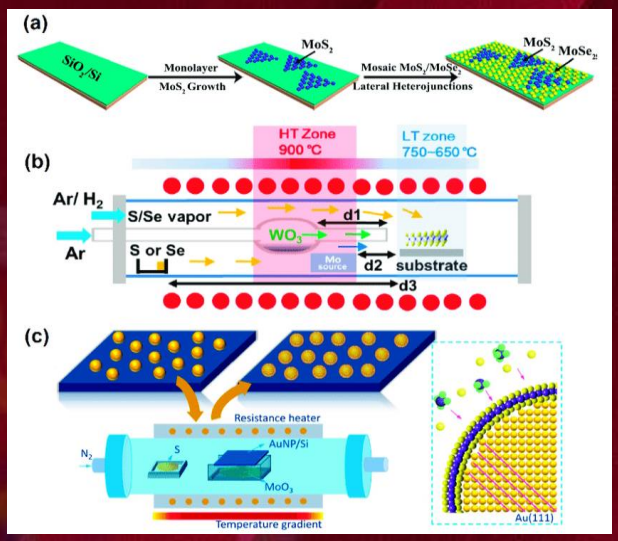
2. Carbon nanotubes can be easily synthesized using atmospheric pressure chemical vapour deposition (APCVD) using Camphor and Methane as sources of carbon. Ferrocene can be used as catalyst. Water vapour can be introduced into the APCVD reactor using a bubbler arrangement with Argon as the carrier gas. Argon can be flown in to maintain an inert atmosphere inside the reactor and to flush out the products of reaction. As grown CNTs can be characterized using scanning electron microscopy (SEM), energy dispersive x-ray spectroscopy (EDX) and Raman Spectroscopy. Very Dense, uniform, highly aligned CNT with length approx 0.15mm can be synthesized with Camphor and Ferrocene.



3 . Further, electrospinning of CNTscan be carried out along with a suitable polymer like PAN or PVA to give a composite thread or a fibre like yarn. Electro spun polyacrylonitrile (PAN) nano fibres and CNT nano fibres can be converted into carbon-CNT composite nano fibre. Various mechanical tests can be performed on this composite thread. From composite (CNT-polymer), a prototype member of the aircraft skin (preferably a fighter aircraft) can be made and proved to be reducing the all- up weight of the aircraft.

CHEMICAL VAPOUR DEPOSITION

4. Chemical vapour deposition (CVD) is based on the fact that the chemical reaction of gaseous species react or decompose or substitute or oxidize at a particular temperature and pressure to give a required deposit on a solid substrate and rest are flushed away as the gaseous waste products. So, the requirement is that all by-products apart from the material to be deposited should be gaseous. The temperature of the reactor should generally be kept between 600 °C to 1000 °C. The reactor consists of a quartz tube of about 50 mm outer diameter. One end of the tube is connected to a control panel which includes flow meters and valves for admission of gases into the tube. The other end of the tube is connected to a rotary pump to create vacuum of 10-3 Torr. An induction furnace with a maximum operating temperature of 1250 ^{0}C can be used. Camphor can be used as a carbon source with Ferrocene as source of iron catalyst for synthesis of CNT. The furnace can be heatedup to 900 °C and held at this temperature for 10 minutes. Thus, the camphor and ferrocene vaporize very quickly i.e., within 4–5 min and pyrolyze at around 900 °C. The CNTs synthesized can be collected on a silicon wafer.



CONCLUSION

5. Many fighter aircraft manufacturers have already invested a lot in this technology which has already reached to an academically mature stage. With India giving a push to 'Make in India' specially in defence sector, it is big time that we should invest more in R&D of this technology which is going to be the future and next game changing technology in defence aerospace industry. A know how of this technology in IAF will help in future acquisitions of 5th /6th generation fighter aircraft.


ABC