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NANO TECHNOLOGY: APPLICATIONS AND IMPACT ON WARFARE

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Introduction

New technologies are emerging rapidly on varied fronts. Quite a few technological advancements are considered as a breakthrough yet not every new technology will alter the way wars are fought. There are some which have a disruptive impact on modern day warfare, in terms of bringing in new paradigms, opening up new challenges, creating new domains of war-fighting, making operational concepts and doctrines redundant, and most importantly having an exponential and dramatic impact. Nano Technology (NT) is one such emerging technology that has the potential to be disruptive, and has applications in almost all facets of warfare. The aim of this paper is *to understand the use of NT and its impact on modern day warfare*.

Technology Basics

"There is plenty of room at the bottom" - said the famous American scientist Richard Feynman in 1959.[1] NT—which broadly involves the manipulation and application of materials and systems through control of matter at the atomic and molecular levels—is emerging as the major focus of scientific and technological innovation for the 21st century. NT is bringing a

revolution across almost all industries ranging from electronics, IT, energy, biomedical, food, agriculture, metallurgy, cosmetics to avionics, automobile, robotics and defence. It is expected to advance weaponry, clothing, light weight metallurgy, miniature robotics, surveillance devices, drones, medical diagnostics, therapeutics, vaccines and computing. These micro-and nano-technologies are being used to develop miniature flying and crawling systems capable of performing a wide variety of battlefield sensor missions, including clandestine ones. Other military applications include armour like fiber, smart helmets, ultra-light material for aircrafts, artificial muscles, etc; all this, coupled with robotics and AI could lead to innovation of devices and applications that could dramatically alter the core essence of modern day warfare.

At nanoscales,[a] material properties differ significantly from those at larger scale. According to the US National Nanotechnology Initiative (NNI), *"Nanotechnology is the understanding and control of matter at nanoscales, at dimensions between approximately 1 and 100 nanometre, where unique phenomena enable novel applications"*.[2] The word *nano* is derived from a Latin word, which means dwarf. The nanometre (nm) scale is generally defined as 0.1 to 100 nm; figure below shows the comparative size of various objects in nano scale. Other comparisons are: head of a pin is ~ 1 million nm, human hair is ~ 80,000 nm, a silicon chip transistor is ~ 45 nm and DNA is ~ 2 nm. It is interesting to note that natural resolution of human vision is about 2000 nm.

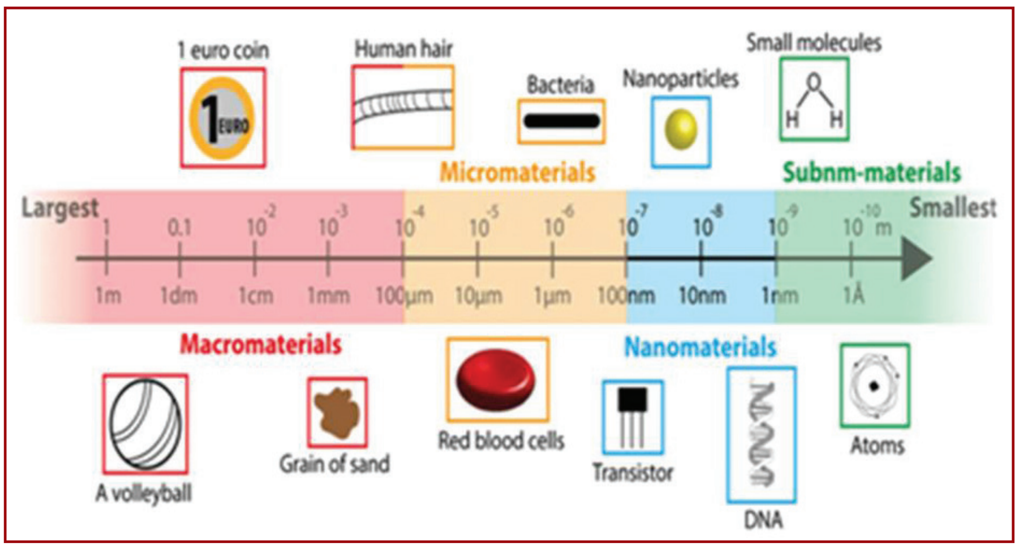

Figure 1: From Macro Materials to Atoms

Source*:* https://www.researchgate.net/publication/263723744_Development_synthesis_ and_ haracterization_of_multifunctional_nanomaterials /figures?lo=1

Bulk materials possess continuous physical properties- same applies to micron sized material (e.g. grain of sand); but at nano scales, principles of classical physics are no longer applicable, rather the quantum mechanics principles apply.[3] The result is that at nano size the same material can exhibit very different properties as compared to bulk size; metals with grain size of ~10 nm are almost seven times harder than grain size of ~100 nm.[4] At times, the properties could be exact opposite- e.g. bulk silver is non-toxic but nano silver can kill viruses on contact; the gold as we see is notably yellow, but once shrunk to nano scales it becomes red if it is spherical or colourless if ring shaped.[5] Basic properties which make way for novel applications of nanomaterials are discussed below:

a 1 nanometre (nm) = 10-9 mtr, i.e. 1 nm is one billionth of 1 mtr

- **Mechanical Properties**. Nano materials exhibit exceptional properties as the grain size becomes too small and can withstand deformation mechanism. The result is increased strength and lighter weight. It leads to enhanced breaking strength at low temperatures and increased elasticity at high temperatures. Nanomaterials can be 20 to 100 times stronger than steel and extremely resilient, but many times lighter. These properties can enable light weight parts for vehicles, aircraft, ships, weapon systems, tanks, protection suits and so on.

- At nano scale, the grain size is much smaller than visible light wavelength and hence special optical properties are exhibited by nano particles. By varying the particle size optical properties can be manipulated for specific applications leading to efficient illumination and display equipment, adaptive camouflage, etc.

- **Size Dependent Properties**. As particles become smaller in size, the ratio of surface area to volume increases and that gives some unique properties to these materials. The surface chemical activity gets a boost and that leads to properties such as resistance to scratch, heat, corrosion and oxidation, higher heat absorption, etc.

- **Electronic Properties**. Nanotubes exhibit different properties depending on the way nano-sheets are rolled to form tubes; it behaves like a metal when rolled along its length, or like a semiconductor when rolled askew.

- **Miscellaneous**. Nanomaterials also exhibit different magnetic and chemical properties which can be exploited for a number of applications e.g. hypersensitive chemical sensors.

The exploitation of NT goes beyond, to tiny and powerful nanosystems that can be made from nanomaterials, e.g. miniature electromechanical systems, nanobots, etc; these small systems can be integrated together to construct bigger systems having features/ capabilities which are far more superior to existing ones. Considering the wide range of applications NT has become a key area of R&D all over the world in the last 10-15 years. As NT is applicable across all industries, it is often called a convergent technology, e.g. DNA silicon chip is a convergence between semiconductor science and biology with applications in medical industry. Since the basic concepts of NT can be applied to any material, the applications and products are only constrained by imagination, research effort and funding.

Applications

NT has become quite popular for use in military applications. Few areas are: smart textiles, lightweight and durable materials for weapons and vehicles, miniature drones, nano satellites for military communications & surveillance, sensors and medical care in the battle field. NT is not yet a matured technology, but its applications across all walks of life are demonstrating a huge impact already. Realising this, governments including military have started investing in research in this novel field in the past two decades or so. As per an estimate over 1,600 NT enabled applications encompassing the areas of food production, industrial manufacturing, social & human engineering, healthcare, electronics, power generation and modern warfare have been put to use.[6] Examples include[7] *"titanium dioxide and zinc oxide nanoparticles in sunscreen, cosmetics and food products; silver nanoparticles in food packaging, clothing, disinfectants and household appliances; carbon nanotubes for stain-resistant textiles; and cerium oxide as a fuel catalyst"*. Global market for NT which was about US$ 80 billion in 2018 is expected to touch US$ 125 billion by 2024.[8] Research efforts by militaries of various countries are aimed to increase their capabilities in the domains of engagement, mobility, protection, logistic sustenance, equipping, survivability, lethality, vehicle and weapons performance, etc. However, it should be understood that a number of applications/ products in NT are still under development and some even in the realm of science fiction, and thus only time will tell how many of these actually fructify as commercial products.

Vehicle Design. NT has huge implications for motor vehicle design. It will lead to weight reduction, improved safety and better fuel efficiency; a resilient chassis, engine & body- coupled with fire resistance properties could build almost a crash proof motor vehicle. NT could also contribute to significantly reduce the environmental impact of exhaust fumes through catalytic properties. Experiments have yielded almost 30% reduction in weight by using advanced high strength steel; it has also been proved that a weight reduction of 10% can lead to almost 6-7% efficiency in fuel consumption.[9] Further, corrosion can also be reduced by use of silicon dioxide nanoparticles in the coating. Due to their large surface area, nano particles in coatings can also reduce the ageing effect of sunlight by absorbing the ultraviolet radiations. Improved tyres can be manufactured using nanostructured soot which will provide better grip but reduced rolling resistance. Vehicle chassis can be made more comfortable- while a soft chassis provides more comfort, hard chassis provides better safety- this contradictory requirement can be met by using smart material, where the viscosity of the material can be controlled in milliseconds. Moving parts friction can be reduced using nano size zirconium powder mixed in oil, thus reducing heat, vibration and noise.[10] Fuel cells (that are pitched to replace car batteries) use platinum as catalysts- however, platinum is very costly material and can be a hindrance to mass usage; scientists are now trying to use carbon-nanoparticle coated graphene to produce the same effect- if successful, this can make today's batteries and fossil fuels redundant.[11] Researchers are also working on using nanotubes to store hydrogen at high density (without liquefying it) to manufacture efficient fuel cells for use in motor vehicles.[12] Scientists at the Department of Energy's Oak Ridge National Laboratory, USA have developed an electrochemical process that uses tiny spikes of carbon and copper to turn carbon dioxide into ethanol;[13] this can have dramatic impact on reducing environment pollution due to vehicle exhaust fumes. The list is endless. Military uses a large number of vehicles for troop transportation & logistic supplies, fighting vehicles like the tanks, armoured personnel carriers, mine clearing vehicles, etc. The possibility of nano material based military vehicles is very exciting; it will lead to less fuel consumption, reduced maintenance, improved armoured protection, better agility, resistance to mine blasts, enhanced protection against missile attacks and better survivability. As per a study in Russia, the protection effectiveness of armour plates can be increased 5-6 times by using NT, at the same time making it lighter.[14]

Sensor/ Surveillance. Miniature sensors with a wide range of advantages can be realised through NT. Such sensors could be used for detection of mines, explosives, NBC contamination, soldier health & location, battlefield surveillance, etc. Interconnected network of nano sensors can create a *surveillance dust that* can clandestinely collect all surveillance data and pass it to the command post for analysis.

Stealth & Camouflage. Nanomaterials can be used in objects or coatings of military equipment, vehicles and aircraft to alter their light/ heat reflection and absorption characteristics- this can reduce their thermal, infrared and visual signatures. Stealth coatings have been developed which can change appearance and colour depending upon the surroundings, thereby camouflaging the soldier/ object/ vehicle; these coatings can be activated by change in humidity, or presence of vapour, or by releasing chemical into the coating. A US Navy research lab has created a material that reacts and adapts to light sources.[15] Coatings can change the reflection pattern of radar signals, thereby reducing the chances of detection. In India, paints developed by DRDO Defence Laboratory, Jodhpur using nanocomposites and nanometals are perhaps the first example of multispectral camouflage paints *"tested in visible, near infrared and thermal infrared regions of the electromagnetic spectrum"*.[16] An adaptive camouflage system will comprise of nanofiber coatings and optical sensors; the fiber changes colour on receiving a signal from optical sensors, thus causing the object to merge with surroundings. The Saratov State University, Russia, is working on a similar project to make a soldier suit that is invisible to thermal imagers and night vision devices.[17]

Drones & Aircraft. NT can help production of more effective and lethal drones. It can enable weight reduction with high structural strength; nano coatings can reduce detection probability; drone can be equipped with nano sensors for battlefield surveillance and detection of hazardous materials. Miniature drones are in the offing, as already covered under the *Drones* category earlier; these mini drones can have utility as *nano-spies* also. DARPA's (Defense Advanced Research Project Agency, USA) nano air vehicle program has developed a 19 gm flying surveillance robot- this could prove critical in surveillance of restricted spaces and urban areas.[18] Adaptive structure morphing is another exciting field where the shape of a drone can be altered in real time as per predefined triggers, or on command. Lighter and stronger nanomaterials will be of immense use in aircraft industry- low weight will reduce fuel consumption, better aviation fuels will be possible by use of nano catalysts, etc.

Advanced Weaponry. NT based weapon system will be light weight and ruggedised; it will incorporate miniature camera, sensors and radar system on the projectile for target tracking with feedback mechanism for course correction. NT has also shown the possibility of creating nanobombs- a new class of miniature bombs that are much more powerful than conventional bombs. US, Russia and Germany are carrying out research on NT-based *mini-nuke* devices, which would weigh probably less than a kg;[19] however, small size also means there is higher probability of these bombs being stolen by miscreants or non-state actors. Russia is said to have developed a high impact bomb using NT, called the *Dad of All Bombs*, which has an impact four times greater than an ordinary bomb, using the same amount of explosive- the effect is comparable to a nuclear bomb less the harmful effects of radiations.[20] In fact the weaponry advancements on account of NT are so scary that someone said *"very serious consideration should be given to promoting an INNER SPACE TREATY [akin to the Outer Space Treaty] to prohibit the military development and application of nanotechnological devices and techniques"*.[21]

Energy and Power. Energy requirements for nano devices will boost the innovation of nano power devices. Conventional Li-ion battery has limited shelf life due to finite charge cycles. Nano-structured anode based power source can give almost 10 times better energy density with significant weight reduction. Log-9, a Bengaluru based NT startup has entered into collaboration with the Indian Defence for production of graphene based batteries which will be used in various defence applications.[22] NT can also enable paper and cloth to have energy storage capability giving rise to the possibility of paper batteries.[23,24] Nanoscale polymer membranes can be used to improve heating/ cooling efficiency of air-conditioning machines- Dais Analytic Corporation, a US company, made it possible by calibrating the size of pores to allow moisture to pass but not the air.[25] Photovoltaic efficiency can be enhanced to a large extent through nano-photonic engineering by using carbon nanotubes in solar panels, as nanotubes are better electrical conductors than copper.[26] Researchers in Canada have developed a spray-on solar panel using quantum dot technology. It means any surface, straight or curved, could be converted into a solar panel and solar panels would become more flexible, even foldable.[27] This could be of immense use in battlefield requirements where rigid solar panels could prove to be a hindrance in soldier manoeuvrability. Miniaturisation and enhanced efficiency of power packs will open up the possibilities of fully electric powered cars, aircrafts, drones and naval ships with more space for armament and weaponry.

Logistics. NT can enhance the efficiency of military logistics supply chain during war. Use of miniature Radio Frequency Identification (RFID) tags, nano sensors to monitor biochemical environment, enhanced battery life and fuel cells, can all add to improved logistics in the battlefield. RFID patches could be used on all battle field supply items and their attrition, consumption and availability could be monitored on real time basis from a central server; this would enable advance warning for provisioning of critical stores at specified locations; RFID with geo-tagging could further provide the exact location of all the stores/ equipment in the battle field and assist repositioning of resources. Nanomaterial based vehicles will require much less maintenance and have reduced fuel/ lubricants consumption.

Tracking. NT enabled small smartphones can help not only in communications, but also to track the soldiers. RFID based nanochips can be used to identify own troops (vis-à-vis the enemy) and also to track those lost/ wounded in the battle field.

Information and Communication Technology (ICT). Miniature packaging and increased density of nanomaterials can provide smaller devices, better communications, faster data processing, low power consumption and higher data storage density. Molecular handling will enable manufacture of single electron transistor, compared to a transistor of today that comprises of millions of electrons. This will greatly enhance the storage density, as a digital storage unit (a bit) can now be represented by an electron spin, rather than the on/ off state of a transistor. This will help to reduce the size of embedded systems in military equipment, reduce the size of on board computers in vehicles/ aircraft and soldier worn systems such as camera, communication and surveillance devices. In the year 2000, a typical transistor was 130 to 250 nm in size; in 2014, Intel created a 14 nm transistor, then IBM created a seven nm transistor in 2015 and finally, Lawrence Berkeley National Lab, US demonstrated a one nm transistor in 2016; soon a computer's entire memory may be stored on a single tiny chip.[28] Communication devices can be miniaturised to the extent of being printed on soldier clothing; it would be foldable, washable and can be rolled and kept in pocket too.[29] NT also helps to reduce the size of electrical conductors by use of carbon nanotube-copper composite which has 100 times current carrying capacity as compared to copper and gold.[30] A nano scientist Young Duck Kim (of South Korea) has developed a nanoscale light-emitting device that can be put on a chip. This brings in the possibility of a photonic computer which could be 10-100 times faster than the fastest computer of today.[31]

Nano Satellite. With NT enabling miniaturisation of electronics, solar panels, power packs, communication and computing devices and reduction in weight of materials without compromise on strength, nano satellites (weighing <10 kg) are becoming a reality. While NASA has been the front runner, ISRO has also launched three nano satellites till date.[32] Such small satellites can be attached to bigger satellites to avoid detection; they can be used for visual and electronic surveillance, imagery, anti-satellite roles, etc. A swarm of such nano satellites can also be exploited for various military uses.

Healthcare. NT has a wide range of applications in the field of healthcare from diagnosis to targeted drug delivery. It can be used for treatment of cancerous diseases by targeting only the malignant cells and avoiding collateral damage to healthy cells. In battlefield, NT can be used to monitor a soldier's vital parameters and trigger drug delivery in measured quantities as per the requirement. These sensors can be implanted in boots, helmet, clothing, socks, gloves, etc. As per a report, DARPA is working on a project for injectable microchips for monitoring soldiers' vital parameters such as stress levels, inflammation, diseases, nutrition and more.[33] Nanobots are also being explored for similar use- they will travel in blood stream and diagnose problems if any, and inject the right amount of drug at the optimum location. Transdermal patches can be applied over skin to deliver nano drugs to the patient through skin. A spray-on nano coating has been developed by Massachusetts Institute of Technology to control bleeding.[34] If a soldier is injured in the arm or leg, thanks to nanofibers in the body suit, the fabric would constrict into a tourniquet and prevent blood loss; the communication device embedded in the body suit could also automatically warn the control centre about a soldier's deteriorating health when body parameters reach critical threshold. Medical imaging techniques (ultrasound, MRI, etc) can have improved contrast and sharper images of tumours[35] by using quantum dots. NT is also helping to promote the use of arthroscopes[b] which will enable surgeries with smaller incisions; research is underway to make arthroscopes smaller than a human hair.[36] Nanowires can detect cancer proteins by just using a small amount of blood, with each wire programmed to be sensitive to a particular cancer marker.[37] Nanobiotechnology is helping modern medicine to progress from regular cure to regenerating tissues- this will open up a host of possibilities like growing of organs outside the body, stem cell treatments, new limbs without prosthetics, etc.[38]

Food Science. NT is finding interesting applications in food industry also. Food packaging lined with silver nanoparticles can kill bacteria; carbon nanotube based sensors lined in packaging material could act as sensors to detect spoiled food; silicate nanoparticles can be used to seal food packets against external gases, thus enhancing shelf life.[39] These innovations, once matured, could be of immense use for supplies to troops at the front line.

Water Treatment. Due to their large and hydrophobic surfaces, carbon nanotubes can be used for removal of contaminants from water and in waste water treatment.[40] A team from IIT Madras has developed NT based arsenic decontamination of water; another team from IIT Delhi has developed a water based self-cleaning technology for use in textile industry.[41] If such technologies can be commercialised, it would be a boon to soldiers in field who often land up in situations where they have to consume water from dirty sources.

Chemical/ Biological Protection. Exposure of soldiers to chemical and biological attacks in the battle field can lead to high casualty rates. NT can be used for protection against chemical/ biological attack. It could be in the form of better sensors and blocking of molecules by plugging pores in clothing. Another method could be to develop anti-reagents that could be used to neutralise the attack vector. Traditional protection suites are heavy, bulky and uncomfortable. Electrospun nanofibers offer properties to act as membrane material for sensing, decomposition and filtration of harmful toxins owing to their lightweight, high surface area and porous nature. Metal nanoparticles (silver, magnesium oxide, nickel, titanium) which have proven capability in decomposing warfare agents can also be embedded in nanofibers for enhanced decontamination, thereby providing operational advantage to soldiers.[42]

Soldier Suit. An ideal battlefield soldier suit would be light weight, flexible but protective against bullets, have biochemical protection, thermal control, adaptive camouflage, health monitoring capability, etc; these qualities can be met through use of nanofiber based textile

b Arthroscopes are pencil size devices used in surgery material. Scientists in China/US have developed a fabric coated with carbon nanotubes which conducts electricity and can be interwoven into clothes to detect blood and monitor health.[43] Such smart fabric may also trigger a distress call to nearby post for medical assistance. Kevlar soaked with *Shear Thickening Fluid* can produce flexible armour which can provide much better protection against ballistics, as compared to Kevlar alone;[44] flexible armour hardens on bullet/ shrapnel impact and regains flexibility once the stress is removed. Battle suit may also consist of a smart helmet, fabricated from carbon nanotubes- this will be light weight with better protection against ballistics, have integrated facial recognition technology, field sensors, night vision device, camera, GPS and communication device. Much of the load of a soldier comes from the many electronic devices he needs to wear on person and all these devices need power to operate- another goal of military research into nanomaterials is to reduce this load through development of lighter, high energy-density batteries.[45] In addition, flexible piezoelectric nanowires can be woven into clothing to generate usable energy on the fly from light, friction and/ or body heat to power the electronic devices.[46]

Nano Fingerprint. Using NT it is possible to identify patterns within materials such as paper, ceramics, metals and plastics. These *fingerprints* can be read using a laser scanner and may be used to identify documents such as passports, driving license, birth certificates, etc; they are near impossible to replicate and will prevent forgery of such documents. Such a technology could also be used in product packaging for unique identification.[47]

Nanofilms. Nano films on glass surface, windows, camera lens, spectacles, etc can make them water repellent, anti-fog, anti-scratch and UV (Ultra Violet) resistant.[48] Such applications are highly suitable for equipment like military vehicle windshield, outdoor/ unattended sensors, gun sights, etc, where battlefield conditions and rough weather can make ordinary optics less efficient.

Agriculture. NT has promising solutions in the field of agriculture; herbicides and fertilisers can be administered using nano capsules- this type of precision farming will be much more cost efficient than traditional spraying methods.

Impact on Warfare

NT has the potential to be the driving technology of future. It is also well recognised that innovations in science and technology often lead to path breaking military applications and therefore have the potential to impact war fighting capabilities and hence, strategies. The impact of NT on various aspects of warfare is discussed below.

Balance of Power. NT is a catalytic technology for future warfare. It impacts every facet, be it weapons, ballistics, healthcare, aircrafts, satellites, drones, surveillance, transportation, armoured vehicles, fuels, logistics, communications, personal kit and so on; therefore, advanced NT capabilities are likely to define the balance of military power between nations. It is estimated that NT could bring 100 times or more enhancement in military capabilities; in future, the *Have-Nots* may well be at the mercy of the *Haves*. Some even say that the potential of NT to alter the balance of power is greater than the nuclear weapons- this will be enabled by a totally new class of weapons that can be realised through NT. Leading nations in the field of NT are already making waves through their innovations and adoption of technology to suit warfare.

Engagement. NT will definitely change the rules of engagement of war. The most significant impact that NT will have on the engagement core skill is through the fielding of light weight and sturdy battle field systems and equipment, including weapons; this would make the combat systems more agile and allow them to have greater firepower. NT based innovations like the miniature drones, nano satellites, nano sensors, mini-nukes, etc will provide newer avenues for engagement with the adversary.

Mobility. Military mobility is certain to get a huge boost due to NT enabled light weight vehicles. Such vehicles will have enhanced endurance not only due to lighter weight, but also due to improved fuels and lubricants. Miniaturisation of equipment means that vehicles can carry more load, have greater ranges, move faster, or have greater opportunities for exploitation in the battle field (as their weight is no longer a limitation on how they are employed).

Protection. The mechanical, optical and electronic properties of nanomaterials might all be used to great benefit. Lighter, stronger armour will enhance survival rates. Light weight armour for personnel (smart soldier suit, helmets, etc) and vehicle protection and will provide enhanced safety features and protection against ballistics and explosive blasts. Nanocoatings can be used to enhance camouflaging, stealth features and thus reduce the visual, thermal, infrared and radar signatures of many military systems. Nano-scale biosensors would give warning against biological and chemical agents. Ultimately, NT may significantly reduce the risk to soldiers, vehicles, tanks, aircrafts, ships and equipment in battle field conditions.

Communication. NT provides a number of opportunities to improve communications capabilities- this is likely to take the form of augmentation to ICT. Any form of miniaturisation of ICT devices (including their power packs) will be beneficial, especially with an increasing prevalence of autonomous and semi-autonomous systems operating in an increasingly networked battle space. In addition, any NT enabled data storage miniaturisation would be advantageous within the digital battle space of future.

Sustainment. The implications of NT for sustainment should not be under-estimated. Most impacts are likely to be secondary effects, such as lighter or more durable vehicles, with improved fuel efficiency, requiring less maintenance; lighter dead weight of vehicles will also result in increased load carrying capacity. The future battle space is likely to require a significantly higher power supply. Any capability to reduce the energy load through lighter vehicles or more efficient systems, or to produce smaller, long-life power sources is likely to give greater opportunities. NT, used in conjunction with bio-information and communication technologies would provide the capability to monitor, sustain and maintain soldier capacity during operations, improving both, the physiological ability and survival rates. The approach towards casualty management will also change with modern soldier healthcare systems in place.

Surveillance. The ability to deploy large number of miniaturised, undetectable and durable unattended sensors (as suggested by the *surveillance dust* concept) is highly desirable in battle field. Similarly, miniature drones, nano satellites can enhance surveillance capabilities manifold, without the danger of being detected by the enemy. Better ICT systems enabled by NT will help in faster dissemination of collected information to the command centre and its further processing and analysis.

Strategy and Doctrine. Induction of NT based systems into the military is itself a big strategic decision. Military doctrines will need to undergo a change to accommodate for induction, deployment and exploitation of such systems. Innovative use of NT systems like the *surveillance dust* will give a whole new meaning to the concept of intelligence collection in the battle field. Similarly, deployment philosophies of miniature drones, nano satellites, etc will need to be worked out, which could be quite different from present day strategies.

Conclusion

There is no denying the fact that disruptive technologies have a definite impact not only on the military warfare but also on the economic development and comprehensive national power. This further dictates the foreign policy choices that we can make. Future conflicts will be driven by these technologies, whether we like it or not, and rather than adopting an ostrich like attitude it would auger well for us as a nation to focus on building up capabilities and the arsenal of new age technologies. It's a long process to include not only identification and development/import of these capabilities, but also the associated policy, doctrinal, organisational, HR changes and the mindsets that accompany. To accomplish this, there has to be a national will that flows from top political leadership, followed by military leadership.

India needs to put its focus on enabling technologies such as NT if it wants to be counted on the global platform. Global aspirations are to be backed by military superiority, only then you get noticed, else be prepared to be overlooked. The political and military leadership would do well to realise this and initiate action plan to take the lead and build up capabilities; if not, the price to pay will be huge, and unaffordable.

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