

Be All You Can Be: The Nano- Enhanced Army

NANOTECHNOLOGY IS JUST THE LATEST POTENTIAL TOOL IN THE QUEST TO PRODUCE THE 'PERFECT SOLDIER'. HERE, DANIEL MOORE DISCUSSES THE HISTORY OF HUMAN ENHANCEMENT AND THE MILITARY, FOCUSING ON HOW NANOTECHNOLOGY COULD NOW BE UTILISED AS A SOLUTION TO LONGSTANDING BATTLEFIELD PROBLEMS.

In 2002, the US Army established an interdepartmental research center at the Massachusetts Institute of Technology called the Institute for Soldier Nanotechnologies (ISN). ISN was charged with developing ways to substantially improve the survival and performance of US soldiers through the use of nanotechnology. This technology would have a point of use in individual soldiers. That is, the technology acts on, affects, or is implanted by an individual.

Much of the activation of the technology occurs automatically, without any conscious input from the soldier at all. This can be accomplished with environmental

a response from the technology. All of these goals seem to be looking for a way to enhance the individual soldier in a way that enables the soldier to go beyond the limitations of natural human action.

Why enhance?

Enhancing humanity beyond its natural limitations is the basic *raison d'être* of technology – that is, all technology adds or enhances what humans can do either individually or collectively. Contra to the Leonardo da Vinci image, Vitruvian Man, as the ideal human state, you can make the argument that enhancing ourselves through technology is what humans, as a species, do. In fact, existing without any technology

somewhat inhuman. The military has for a long time been a catalyst for technological development / human enhancement. The typically clearly defined goals of military action and the drive for constant improvement on those goals have long interlocked the military with technology.

Individual and group enhancement, making the soldier and larger units "better," has been a key part of military strategy for as long as we can look back. For example, the Greek Hoplite realizes that his hand and fingernails aren't effective enough in punching and stabbing his enemy, so he enhances the power of his hand with a sword. However, he also realizes that



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against other swords isn't good enough, so he extends the blocking ability of his arm with a shield. Then, he thinks that it might be useful to begin the attack when he is farther away from the enemy, so he equips himself with a spear. Furthermore, the shield might not provide the ultimate protection – either because it can't reach his back or because he will be blindsided by an attack – so he enhances the toughness of his skin with body armour. And so on.

We can shift ahead a few centuries and look at the Medieval Knight and Longbowman. Sometimes, military technology development leads to specialization. With the Medieval Knight, the body armour enhancement has led to the development of chain and plate mail that covers the entire body, a better sword and a better shield. These enhancements provide protection, but less mobility, making the knight a powerful shock weapon. The longbow has also been developed, allowing for the inexpensive deployment of a large number of missile troops. Protected by distance, the longbowman does not require as extensive a body armour as the knight.

Another few centuries later, we can look at the British soldier. The development and use of missile weapons powered by gunpowder, such as the rifle, led to the obsolescence of medieval knights and drastically reduced fighting with melee weapons (though the bayonet still provides for close up fighting). The more modern U.S. soldier has much more powerful missile weapons at his disposal (and grenades of various types). Body armour is also much more sophisticated. Other types of enhancements have also entered into general military use – including enhanced eyesight providing the ability to see better at night and to see/enhance different wavelengths of light.

The point is that all technologies provide an enhancement to humanity. But all of these aren't what we mean by "human enhancement." It is a difficult line to draw, probably because there isn't a line at all but a continuum upon which the technologies lie. We can look at different ways to distinguish military technologies: purpose of use (defensive or offensive), level of use / impact (civilization or individual), type of use (shock or missile), amount of control required (human controlled or autonomous

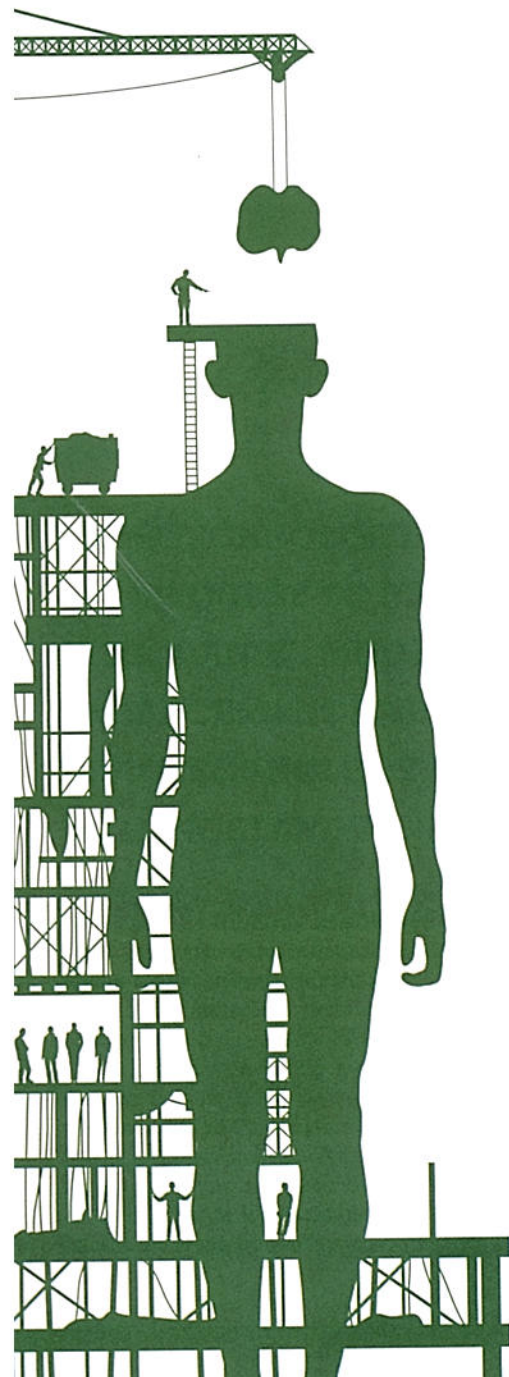
system), duration of use and/or impact (temporary or permanent), and the locus of use (internal or external). This isn't a comprehensive list, but it represents several ways of analyzing military technologies that are relevant to a discussion of human enhancement (and to comparing different types of technology). For example, a pistol is an offensive weapon that acts on an individual, whereas a protective wall is defensive and protects on the civilization level. Automated defence shields are missile weapons requiring minimal human input, and swords are shock weapons that require extensive human input. Battlefield medicine is a temporary fix that acts internally to the body, while traditional limb replacement can be seen as a permanent fix that is external to the body.

How and why nanotechnologies are being deployed

When talking about nanotechnology, human enhancement and the military, it is also important to understand what uses the military might have for technology. After all, technologies are not created in a vacuum. They are created to solve problems and enhance capabilities. This is also true for military technologies. Some of the "problems" that exist in the military and are related to human enhancement are:

- **Soldiers need more effective tools to accomplish their goals;**
- **Soldiers carry a heavy load, averaging just under 100 lbs in combat operations;**
- **Threats to soldiers can come unexpectedly, suddenly, and can cause injuries that cannot be healed quickly;**
- **Sleep deprivation hurts soldier performance.**

It should be noted that none of these is a new challenge to the military. Many of the technologies described earlier were developed in attempts to provide a novel solution to these problems. Different times and cultures have developed different technologies that solve these challenges to different degrees and with different methods. Furthermore, major advances in technological solutions to these problems have shown the ability to create major changes in battlefield outcomes, tactics, and situations. As



mentioned, the longbow is a perfect example of this. Developed in Wales, it introduced a new form of artillery fire and contributed significantly to the removal of armoured knights from the battlefield.

As we will see, nanotechnology offers a significant number of technological avenues towards human enhancement. It allows for the creation of tools that enable more permanent effects and that are continuous or always on/available. Nanotechnology also enables technologies to move towards more internal use and impact because of its small scale and capabilities. It also leads to technologies that are relatively ubiquitous. Nanotechnology offers new and transformative directions in military technology because it leads to enhancement in humans that is more permanent and more internal. It helps to make strong inroads into previously difficult to directly address problems, such as the managing of individual mental states. If we look at the list of problems above and examine what nanotechnology based solutions might look like, then we can begin to develop a picture of a nanotechnology enhanced military.

More Effective Tools

Soldiers need more effective tools to accomplish their goals, that is, they need more effective weaponry. A specific example of nanoscale materials showing their impact in weaponry is nanoaluminium. Bulk-scale aluminium contains aluminium atoms that cover roughly one-tenth of 1 percent of the surface area. Nanostructured aluminium contains aluminium atoms that cover roughly 50 percent. More atoms on the surface create more sites for chemical reactions to occur. This is used in conjunction with metal oxides such as iron oxide to create superthermites, which increase the chemical reaction time by three orders of magnitude. Therefore, greater amounts of energy can be released, creating more powerful conventional explosives and faster moving missiles and torpedoes (so fast, in fact, that they can bypass evasive actions).

Reducing Load Weight

Soldiers typically carry a heavy load during combat operations. Historically, load size has been a severe limiter of army mobility. For example, Hannibal had more than 2000 head of cattle to support his army of 30,000 men. By simply making devices smaller and lighter, the soldier can be made

more mobile and have a smaller logistical footprint, allowing for far greater supply lines. The average present-day soldier carries in excess of 100 pounds of equipment while on assignment. Much of this weight is due to the electronic equipment (including communication equipment) and power supplies (usually batteries) used to power them. Through the use of smaller, lighter equipment, this weight could be reduced dramatically without a sacrifice in functionality; the soldier could therefore move more quickly and/or further (in the same amount of time). Much of this weight reduction can be accomplished by reducing the scale of the power generators that the soldiers have to carry. For example, nanoscale power generation has been recently demonstrated by utilizing an array of piezoelectric nanowires. By converting mechanical, vibrational, or hydraulic energy into electricity, these "nanogenerators" can be used to power the electrical systems carried by the soldiers.

Sudden threats, and battlefield injuries

Threats to soldiers can come unexpectedly, suddenly, and can cause injuries that cannot be healed quickly. Traditionally, shields and body armour have been the solution to providing direct protection to soldiers. Nanoscale materials can be made out of flexible polymers and nanocomposites to form nanoscale trusses. Woven into a battle suit, these materials would provide light weight flexible body armour. This would provide ample protection without significant loss of performance due to weight. For example, recently, GE has demonstrated a SiC matrix with nanoscale SiC fibers capable of stopping a bullet. Furthermore, nanotechnology allows for more direct and immediate detection and treatment of injuries. Using designed nanoscale polymers that have an electrorheological response, mechanical actuators could transform a material from flexible and pliant to nonpliant and armour-like almost instantaneously. This could be used to automatically form a cast or tourniquet to treat injuries and wounds. This same material response could be used to give CPR, if necessary, with little to no human input. This mechanically active exo-skeleton could have more uses than just injury mitigation and treatment – serving as exomuscles to augment a soldier's physical strength and movement.

Sleep Deprivation

According to a JASON report, "the most immediate human performance factor in military effectiveness is degradation of performance under stressful conditions, particularly sleep deprivation." If an opposing force had a significant sleep advantage, this would pose a serious threat... Suppose a human could be engineered who slept for the same amount of time as a giraffe (1.9 hours per night). This would lead to an approximately twofold decrease in the casualty rate." Human enhancement with nanotechnology can have a major impact here. Even the simple detection of fatigue, lapses in attention, and changes in neurological behavior would allow battlefield commanders to have better knowledge about the forces under their command. Nanoscale sensors can be used to detect this fatigue in individual soldiers. This can be done by monitoring the brainwave patterns, but it can also be done more simply by closely monitoring, in real time, muscle response, eye movement, chemical levels in the body, and other triggers and suggestions of fatigue. DARPA is investing in what it refers to as "metabolically dominant" war-fighters that will "be able to keep their cognitive abilities intact, while not sleeping for weeks. They will be able to endure constant, extreme exertion and take it in stride." By allowing for targeted drug delivery systems, nanotechnology provides access to chemical methods to enhance and control the mental states of soldiers with minimal side effects.

In conclusion, nanotechnology leads us towards military technology that enhances humans more permanently and more internally. More efficient weaponry, lighter loads and devices that allow increased capability without sacrificing mobility, energy absorbing and electromechanical materials acting as an exoskeleton to help automatically protect the individual, and some management of the mental states of individuals are all made possible by the shrinking size and increasing technological capabilities that nanotechnology provides us with. **1**

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