BIT 5514: Leading Technology Transformation

Professor David Simpson

**Nanotechnology in Defense**

Sawan Chawla

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**Introduction:**

The Department of Defense (DoD) currently finds itself at a critical juncture in America today. A combination of geopolitical shifts as well as internal issues puts the DoD and the United States of America as a great power at risk. Major geopolitical plus internal concerns including the great power competition with the US’ adversaries, budgetary constraints within the organization, climate change and personnel issues (Garamone, 2024; Lynch & Saunders, 2020). Addressing these challenges requires an innovative approach and use of technology that has not been tapped into before.

Nanotechnology offers a viable solution to many of these key issues. In terms of geopolitics, Nanotechnology can not only serve as the next big weapon of mass destruction in an arms race but serve as a potential innovator to advance the military in terms of next generation capabilities and enhance our defensive through new break through processes (Kaginele, n.d.; Hilton, 2022). When it comes to internal issues, nanotechnology can be used to cut costs on supply chains while also automating or reducing the human element needed for manual complex tasks that are otherwise a strain on the budget and improve the defense industrial base as well through the same similar methods (Hilton, 2022). In terms of climate change, nanotechnology can be used for various tasks including capturing elements that are hostile to the environment using this technology through having it convert these hostile elements into something useful, create advanced materials that can store energy from scratch as well as on the fly and repair damage to materials, objects, weapons, etc. on the fly (Nanografi, 2024). Nanotechnology can address personnel issues by making safety features that will make it easier for medical personnel to save active members on the frontlines, while also providing advanced tools that service members can use to enhance combat effectiveness (Abaszadeh et al., 2023; Hilton, 2022).

**Overview of Organization:**

The Department of Defense (DoD) is a large government agency in the United States in charge of the defense of the country, second only to the president. The mission of this organization is provide the military forces needed to deter war and protect the nation’s security. Currently the organization has a budget of $841.4 Billion with 3.4 million service members and civilians (Department of Defense, 2025). The DoD’s primary focus is on maintaining its technological superiority over adversaries, enhancing military defensive and offensive capabilities, as well as protecting national interest while maintaining deterrence against these adversaries (Lynch, 2024). This government collaborates with various agencies within the government to achieve its goals as well. The DoD traces its origins back to pre-revolutionary times, playing a crucial role in the development of the country as it navigated complex conflicts in its 300-year history. It is composed of 11 combatants. Some of the major commands include Army, Marine Corps, Navy, Air Force, Space Force, Coast Guard, and National Guard (Department of Defense, 2025). The DoD plays a key role in the development of key technology as well since weapons such as nuclear bombs, B-2 Spirit Bomber, F-35 Fighter Jet, and so on (Lynch, 2024). It has also played a role in the foundation of Defense Advanced Research Project Agency (DARPA) (About DARPA, 2022)

**Nanotechnology:**

Nanotechnology is an emerging technology that can manipulate matter, cells and other materials as well as create or repair or alter them on a very small scale. It usually includes very small robots conducting these actions (Liyakat, 2024). Currently, the DoD is focused on maintaining a technical edge in this field. Major players like Russia and China are making significant advancements in the field with China dominating. Additionally, Iran, India and South Korea are also making headways in research as well as applications of nanotechnology in the field (Research and Markets, 2025). Theres the potential for dual applications of nanotechnology in both civilian and military use. In military use, nanotechnology can be used to develop a weapon of mass destruction that may be utilized to destroy a city or region via nanoprobes that deconstruct the area around it. This would be a dangerous weapon that certainly would require a doctrine (or equivalent to the Geneva Conventions) that in which all countries should follow to ensure proper ethical use (Kaginele, 2023). Nanotechnology can also be used by the DoD for self-repairing armor in which damages to personnel during combat can be repaired by the nanotechnology itself, reducing the workload on medical personnel while also increasing life expectancy during combat (Liyakat, 2024). It can also address current issues plaguing the DoD in terms of the development of environmentally unfriendly hardware that otherwise can be resolved through nanotechnology carbon or other forms of capture (Nanografi, 2023). This same technology can also be used to repair damage to things like airplanes or warships during combat as well as streamline construction through the generation of synthetic material for this hardware (Hilton, 2022). The applications are far reaching with nanotechnology although there is a certain degree of risks associated with this technology.

**Risks of Nanotechnology:**

The emergence of nanotechnology presents a variety of risks and advances particularly in terms of military applications. One of the most premier things about this technology is the capability for weapons of mass destruction. Evidence indicate that nanotechnology can be utilized to develop miniaturized weapons that might be harder to detect. These weapons may give rise to small nuclear weapons that, if deployed, will escalate global tensions while also endangering countless lives (Hilton, 2022; Kaginele, 2023; Kosal, 2014). In addition, the development of bio and chemical weapons that are difficult to cure or clean up amplifies this concern. These weapons have the side effect of damaging or harming human life and environmental life in areas targeted by these weapons as well as damaging human habitation in that region for a long time through these weapons derived from nanotechnology (Kosal, 2014). The idea of devising such a weapon in which cures may not exist also includes a stipulation that no accidental release can happen, or else the costs associated with this will be immense (Kaginele, 2023). Another risk is also the negative impact some of the weapons may have on a region due to the nature of it being developed by nanotechnology, especially if used deliberate deterrent on the scale that nuclear weapons are used. Any sort of error when making, using or developing key technologies, especially with nanotechnology, can have devastating consequences on people, regions and to life on Earth in general as well as threaten global stability (Lynch, 2024; Kaginele, 2023).

**Vision for Transformation:**

The DoD should target for a measured vision that balances superiority in the field to protect American interest with recognition of its dangerous implications including ethical usage and adherence to keeping the technology from falling into the wrong hands. This would involve developing unmatched destructive capabilities in the equivalent to nuclear weapons but for nanotechnology with adherence to not use in the case of a first strike as well as adherence to international laws. It would align with the DoD mission of having strong deterrence to war as well as ensure the nation’s security (Department of Defense, 2025). Such development must proceed alongside international agreements or a DoD-specific doctrine to ensure responsible use of nano weapons (Kosal, 2014). While developing superior weapons of mass destruction to keep a technological superiority over the US adversaries and deter war, the DoD should also utilize nanotechnology to enhance its military capabilities in the form of medical tools for the most severe injuries on the battlefield that can self-heal rather than through manual labor, self-repairing vehicles that can likely survive engagements rather than be lost permanently, progress the army towards more efficient measures that have historically plague and mitigate the constraint of the DoD on the budget through cost cutting measures (Abaszadeh et al., 2023; Kosal, 2014; Liyakat, 2024; Lynch, 2024). These measures to limit constraint on the budget include enhance and automated fabrication of key tools from more environmentally friendly means given nanotechnologies capability to remake key elements through its rearrangements of molecules. The advantage of this measure includes cutting costs on the production front while also being able to reduce the need for manual labor and other manual processes as well as limiting the constraint on environmental issues (Nanografi, 2023). In regards to tools for doctors, doctors will be able to inject lifesaving coded nanotechnology that essentially does all the major work for doctors as well as what they couldn’t do when dealing with live battle injuries that can be at times much more difficult than traditional methods of healing while also enhancing the health of personnel in the process. Self-repairing vehicles will be able to save the DoD a lot of money in terms of covering losses during battle as these things will be able to repair through nanotechnology coating as well as adapt to even various environments as well as situations through this, allowing for multipurpose vehicles while also mitigating losses and even improving the safety of personnel operating this vehicle (Abaszadeh et al., 2023; Liyakat, 2024). These measures address the major issues plaguing the DoD while focusing on its mission statement simultaneously. This also protects the US interests responsibly by keeping a technological edge while also having a focus on ethical uses through adhering to conventions made by the international community as well as utilizing creative nanotechnology use cases to apply to both the military and civilian sectors. Objectively, to achieve these notions, the DoD must have a thorough implementation plan and success criteria for this.

**Implementation Plan and Success Criteria:**

Implementing this technology into major elements of the DoD will not be easy as the structure has been refined and expanded over the United States’ 300 years history (Department of Defense, 2025). Existing procurement of research and technology will need to be thorough but also streamlined simultaneously. The use of tools like generative AI can help aid in that research through the use of generative AI that can access everything but has a highly encrypted security but also is able to retrieve key information to aid in research. It could also be best that the DoD during experimentation also uses generative AI to help streamline that process through providing results and using it for suggestions. This helps refine as well as streamline the process with thorough evaluation while allowing research to be thorough and accurate without any hallucinations given that we are able to address them through determining when the information is accurate and when its hallucinated. Through the prioritization of this technology, the DoD can foster a clear culture of innovation through its focus on research and experimentation, which upon completion will lead to solutions using nanotechnology being devised. Resistance to change can likely be overcome with small scale introduction in small areas before quickly expanding upon proven results and predictions from generative AI (Bean, 2024). Given that the United States was the leading researcher in Nanotechnology, it would be in the DoD’s best interest to do what it takes to to maintain superiority by increasing funding to that field over time (in the timeline the next couple years). Additionally, by doing so it keeps us up with our adversary, China, who is also researching and has recently surpassed the US in that field (K. Siddiki, 2022). As new experiments yield results, and breakthroughs occur leading to the creation of the first nanobot (at least 5 or more years down the line), it is imperative that the DoD begin looking into not only adding fail safes to the technology but also begin the process of using it for making weapons, as well as its integration as well into experimental weapons meant to deter the US adversaries. Next, the DoD should then invest following the completion of key weapons research and development with nanotechnology, the enhancements to the army including medical tools, suits, weapons with advanced rounds that can self-replenish, as well as its additions into a self-repairing mechanism for future and current vehicles plus hardware. These actions following the creation the first nanobot are expected to take at place over the next 10 to 15 years given the speed of research and development. While this estimate is based on projected research and development trajectories, it aligns with the pace of past biomedical and military-grade technological breakthroughs, as discussed in recent reviews of nanotechnology’s potential (Abaszadeh et al., 2023 & K. Siddiki, 2022). To train people on this technology, the DoD will utilize personnel who are specialized in the research as well as is working with nano-technology. The skills required for such an assignment will require an analytical mind experienced in some degree of computer science or chemical and bio engineering sciences plus any general engineering in order to work with this technology. These individuals will be on the frontlines to learning and developing this technology as well as spearheading its implementation into other branches. Any new skills developed from nanotechnology might involve certain movements in regards to using nanotechnology among personnel on the frontlines of battle, its utilization as key medical tools which means doctors may need to have an understanding of the technology but how to direct it to do key tasks that otherwise assist someone healing including a fundamental understanding of the technologies impact on human biology, and a fundamental understanding of the technology itself when it comes to building weapons, involving its equivalent of weapons of mass destruction. The DoD will succeed in this technology and win the nanotechnology arms race if they are able to maintain robust funding for the program as well as is couple years ahead of adversaries in the development of key advances including systems plus lead the way in the field in terms of breakthroughs or experimentation that leads to applications in both military in addition to civilian sectors. Lastly, it will also be considered a success if nanotechnology is successful in providing deterrence of war while protecting the security of the United States (Department of Defense, 2025).

**Conclusion:**

In the age of technology, nanotechnology is a key emergence in this era that will define the next decade of advancement and be a key part in the major changes to society, alongside AI. The Department of Defense (DoD) finds itself at an difficult crossroads to adapt this technology for the reasons of maintaining superiority US’ adversaries, budgetary constraints within the organization, climate change and personnel issues. While the technology has benefits in the form of advanced tools for doctors, self-repairing capabilities on vehicles in operation, a major saver in terms of environmental and budget constraints, it must also be considered the ethical implications. This emerging technology has the ability to also function as a major destroyer, capable of destroying cities, regions and so on. Its abilities to create and destroy must be carefully explored while the DoD focuses on achieving its mission goals of maintaining the deterrence of conflicts while protecting America’s interest. To conclude, it is best that in the face of maintaining the advantage while ensuring the ethical complications, the DoD and by extension the government should continue to invest in this technology but go further with the ideas outlined in this paper in the name of security.

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