

## ***Innovative technologies in the development of explosives and pyrotechnics for modern warfare***

**Author:** Doris Dasović; military applications, explosives engineering; military engineering, technology studies. The views contained in this article are the author's alone and do not represent the views of Croatian Ministry of Defense.

**Abstract:** Explosives and pyrotechnics play a critical role in modern military technology. Recent advancements in nanotechnology, artificial intelligence, and 3D additive manufacturing are transforming their development, applications, and safety. This paper examines how these disruptive technologies shape the future of explosives while addressing the challenges of their ethical application. Special attention is given to AI's ability to detect, deactivate, and defend against explosive threats, significantly impacting military doctrines. The geopolitical and geo-economic implications of these technologies on global power balance are also analyzed.

**Bottom-line-up-front:** Disruptive technologies are revolutionizing explosives, requiring careful consideration of their risks and applications.

**Problem statement:** How do innovations in explosives and pyrotechnics challenge traditional military applications and doctrines?

**So what?:** The military, policymakers, and researchers must collaborate to responsibly develop and implement these technologies to modernize capabilities while addressing ethical challenges.

Explosive and pyrotechnic systems are key components of military technology. In the last few years, new technologies have brought disruptive change, making their applications and safety pivotal. This paper examines how innovations such as nanotechnology, artificial intelligence, and 3D additive manufacturing shape the future of explosives. One significant application of artificial intelligence lies in its ability to detect, deactivate, and defend against explosive threats, altering traditional military doctrines.

Special emphasis is placed on the complications and hazards associated with applying these technologies, particularly the potential proliferation of advanced explosive devices and their misuse by non-state actors.

Additionally, the geopolitical and geo-economic dimensions of these disruptive innovations and their impact on the global balance of power are considered.

This work presents a comprehensive review of new technologies in the field of explosives and pyrotechnics, explores the threats and ethical challenges they pose, and offers recommendations for further development and the responsible management of innovations in military structures and technology. The goal is to highlight the critical role these technologies play in modernizing military capabilities and enhancing global security.

#### Endnotes

- [1] M. Marciniak, "The 3D Printing in Military Applications: FDM Technology, Materials, and Implications," *Advances in Military Technology* 18, no. 1 (2023): 45–58
- [2] Hossain, Khan Rajib, et al. "Application of 3D printing technology in the military." *Journal of Chemistry Letters* 4.2 (2023): 103-116.
- [3] Bird, D. T., and N. M. Ravindra. "Additive Manufacturing of Sensors for Military Monitoring Applications." *Polymers* 2021, 13, 1455."
- [4] Ramsden, Jeremy J. "Nanotechnology for military applications." *Nanotechnology Perceptions* 8.2 (2012): 99-131.
- [5] Tate, Jitendra S., et al. "Military and national security implications of nanotechnology." *Journal of Technology Studies* 41.1 (2015): 20-28.
- [6] Kusnezov, Dimitri, et al. "Nanotechnology and the Military." *Defense Horizons* 30 (2003): 1–8
- [7] "Nanotechnology in the Military," AZoNano, last modified November 11, 2021, <https://www.azonano.com/article.aspx?ArticleID=3028>.
- [8] "Governing Military AI Amid a Geopolitical Minefield," Carnegie Endowment for International Peace, last modified July 2024, <https://carnegieendowment.org/research/2024/07/governing-military-ai-amid-a-geopolitical-minefield>.

[9] “Artificial Intelligence - Defense.gov,” U.S. Department of Defense, last modified 2023, <https://www.defense.gov/Spotlights/Artificial-Intelligence/>.

[10] “Nanotechnology and the Military: How Tiny Materials Can Win Wars,” NanoChem Group, last modified November 11, 2021, <https://blog.nanochemigroup.cz/nanotechnology-and-the-military-how-tiny-materials-can-win-wars/>.

[11] “The Coming Military AI Revolution,” Army University Press, last modified May 2024, <https://www.armyupress.army.mil/Journals/Military-Review/English-Edition-Archives/May-June-2024/MJ-24-Glonek/>.