Disruptive Technological Revolution and Future Trends Outlook: Postprint

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Abstract

[Purpose/Significance] Science and technology are the most active and revolutionary factors in defense and military development. Breakthroughs in disruptive technologies have further evolved the principle of "technology determines tactics" into "technology determines strategy." [Method/Process] President Xi pointed out in his speech at the ceremony celebrating the 90th anniversary of the founding of the People' s Liberation Army (PLA): "We must comprehensively implement the strategy of strengthening the military through science and technology, adhere to the strategic foundation of independent innovation, aim at the forefront of global military science and technology, strengthen forward-looking planning and design, accelerate the development of strategic, frontier, and disruptive technologies, and continuously increase the contribution rate of scientific and technological innovation to PLA building and combat effectiveness development."This provides a scientific fundamental guideline for the innovation-driven development of disruptive technologies. [1][Results/Conclusion] This paper makes relevant predictions regarding the development trends of disruptive technologies and elaborates on their impact on future warfare.

Full Text

Preamble

Changing the Game Rules, Subverting Traditional Perceptions, and Promoting Transformative Development: An Outlook on the Disruptive Technology Revolution and Future Trends

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Abstract:
[Purpose/Significance] Science and technology are the most active and revolu-

tionary factors in national defense and military development. Breakthroughs in disruptive technologies are pushing the paradigm of "tactics determined by technology" toward "strategy determined by technology." [Method/Process] As President Xi Jinping stated in his speech marking the 90th anniversary of the founding of the People' s Liberation Army: "We must fully implement the strategy of strengthening the military through science and technology, adhere to independent innovation as the strategic foundation, aim at the frontiers of global military technology, strengthen forward-looking planning and design, accelerate the development of strategic, frontier, and disruptive technologies, and continuously enhance the contribution rate of scientific and technological innovation to the development of the People' s Army and its combat effectiveness." This provides fundamental guidance for the innovation-driven development of disruptive technologies [**?**]. [Result/Conclusion] This paper forecasts the development trends of disruptive technologies and elaborates on their impact on future warfare.

Keywords: disruptive technology, strategic deterrent, game rules, innovation-driven
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1 Overview of Disruptive Technologies

Disruptive technology is a concept first introduced by Harvard Business School professor Clayton Christensen in 1995. In the engineering domain, disruptive technologies often emerge from the fusion and innovation of various technologies. In the military domain, the U.S. Department of Defense defines disruptive technology as "technologies or technology clusters that solve problems in ways that rapidly break the balance of military power between adversaries" [**?**]. The concept can be summarized as innovative technologies capable of disrupting war rules, industrial models, business processes, application domains, and service types.

A technology must possess four key characteristics to be considered disruptive. First, it must be technologically innovative, producing disruptive effects on existing traditional or mainstream technological approaches. Second, it must be forward-looking in its domain, breaking conventional technical thinking and development paths to achieve leapfrog development beyond incremental technologies [**?**]. Third, it must enable breakthrough applications that accelerate development speed or enable staged technological progress. Fourth, it must have profound impact, with the capacity to alter war rules, industrial models, business processes, application domains, and service types.

From the age of cold weapons to today' s information warfare era, disruptive technologies have emerged at different stages, including bronze and iron casting in the cold weapons era, firearms and artillery in the age of gunpowder, and internal combustion engines, radio technology, and electric power in the mech-

anized warfare era. In particular, the breakthrough in nuclear weapons technology and its disruptive effects significantly transformed the rules of warfare. An examination of the roadmap of these disruptive technologies reveals a clear pattern: disruptive technologies dominate and transform the forms of warfare, while the demands of war simultaneously nurture and catalyze the emergence of disruptive technologies.

2 Forecast of Disruptive Technology Development

Since the beginning of the 21st century, disruptive technologies such as hypersonic vehicles, space vehicles, directed energy weapons, 3D printing, cyber-electromagnetic space confrontation, quantum technology, and brain-computer interfaces are poised to change the "game rules" of combat. These technologies will give rise to new military thinking, strategic theories, and operational concepts, driving transformations in operational styles and forms of warfare [**?**]. As these technologies continue to achieve breakthroughs and find military applications, future warfare within a certain timeframe will evolve into intelligent joint operations that organically integrate full-dimensional combat forces across land, sea, air, space, and electromagnetic domains, all under the backdrop of nuclear deterrence.

2.1 Domestic and International Development Overview

The United States leads the world in disruptive technology development. In May 2013, the McKinsey Global Institute released a report on "12 disruptive technologies that will transform life, business, and the global economy by 2025," highlighting cloud technology, advanced robotics, genetic technology, energy storage, and 3D printing. In the first half of 2014, *The National Interest* magazine identified "five pieces of equipment and technologies that could transform the form of warfare for decades to come," including "super stealth" or "quantum stealth" materials, electromagnetic railguns, and highly autonomous unmanned systems. In November 2014, *National Defense* magazine argued that in an era of global instability, ten disruptive technologies—including new energy technologies that provide unlimited power for military systems, hypersonic weapons, and new biomedical technologies—would have significant impacts on future military operations.

Russia is actively responding to evolving threats through emerging defense technologies, with research and development focusing on directed energy weapons, geophysical weapons, genetic weapons, and psychological weapons. China's 13th Five-Year National Science and Technology Innovation Plan has identified next-generation information technology, advanced manufacturing, new materials, advanced and efficient biotechnology, and clean and efficient energy technology as essential components for building a modern emerging industrial technology system [**?**].

2.2 Future Outlook on Disruptive Technologies

Future disruptive technologies are converging on several key areas: novel materials, next-generation information technology, space technology, cyberspace technology, hypersonic technology, directed energy technology, and biotechnology. These technologies are characterized by being driven by new military-technological revolutions and dominated by national security strategies.

2.2.1 Metamaterials Metamaterials are artificial composite materials or structures that achieve extraordinary physical properties—such as frequency selectivity and anomalous refraction—not found in conventional materials through ordered structural design at key physical scales. These materials can comprehensively enhance the stealth and penetration capabilities of missile weapons while improving the efficiency and anti-jamming performance of space communication and radar antennas.

2.2.2 Atomic Gyroscope Technology This technology utilizes atoms to measure angular velocity in a new type of gyroscope. Atomic interference gyroscopes offer precision and sensitivity four to five orders of magnitude better than optical and electromechanical gyroscopes, dramatically improving the accuracy of current inertial navigation systems. This technology will significantly enhance the ultra-high-precision navigation capabilities of weapons and equipment.

2.2.3 Reusable Space Vehicle Technology These vehicles can traverse the atmosphere and travel freely between Earth and space, remaining in orbit or maneuvering for extended periods as needed. They can perform complex missions including satellite launch, on-orbit servicing, reconnaissance, anti-satellite operations, and ground attacks. Reusable space vehicles will become powerful tools for seizing space supremacy in future warfare.

2.2.4 Hypersonic Vehicle Technology These vehicles operate at speeds greater than Mach 5, at altitudes of 20–35 kilometers, with ranges of 1,500–2,000 kilometers. In principle, they can render traditional missile defense systems ineffective, thereby substantially improving the penetration capabilities of modern weapons.

2.2.5 Laser Weapon Technology Laser weapons are directed energy weapons that attack targets by emitting laser beams in a specific direction. They offer exceptional performance characteristics including rapid response, flexibility, precision, and resistance to electromagnetic interference, enabling unique roles in electro-optical countermeasures, air defense, and strategic defense.

2.2.6 High-Power Microwave Weapon Technology These weapons disrupt and damage enemy information-based combat systems equipped with pre-

cision electronic equipment, and can also inflict casualties on personnel, by directionally emitting high-power electromagnetic pulses.

2.2.7 Cyber-Electromagnetic Space Countermeasure Technology This technology employs the electromagnetic spectrum and networked information systems as physical carriers for applications primarily involving information acquisition, processing, distribution, theft, and tampering. Cyber-electromagnetic space countermeasures can enhance the effectiveness of system-of-systems combat capabilities based on information systems.

2.2.8 Brain-Computer Interface Technology This technology establishes a direct connection pathway between humans and external devices, fundamentally changing interaction modes. Brain-computer interfaces can be applied to remote maintenance and control, space operations, and direct control of weapons and equipment by the human brain, minimizing reaction time between sensors and shooters and thereby significantly enhancing the intelligence level of weapons and equipment while transforming human-machine relationships.

3 Impact of Disruptive Technologies on Future Warfare

The development of disruptive technologies will influence the direction of national defense security strategies and military doctrines, affect the construction of new-quality combat forces, and enhance both strategic deterrence and actual combat capabilities. Consequently, this technological domain has evolved into a focal point of strategic competition among major world powers.

Disruptive technologies will fundamentally transform the mechanisms for winning wars. Future warfare will no longer be about the simple accumulation of combat forces and scale, but rather about military confrontation conducted simultaneously across land, sea, air, space, and electromagnetic dimensions. New-quality combat forces such as hypersonic weapons, directed energy weapons, artificial intelligence weapons, cyber-electromagnetic attack weapons, and aerospace combat weapons will subvert traditional perceptions of warfare from the perspective of winning principles, bringing about transformations in operational styles and creating new strategic deterrence capabilities.

Disruptive technologies will establish a new strategic balance under the backdrop of nuclear deterrence. While nuclear weapons remain instruments for maintaining world peace and great power competition, new-quality conventional combat forces will develop into asymmetric means for balancing adversaries. Therefore, achieving breakthroughs in disruptive military technologies and developing new-quality conventional combat forces to strike critical nodes in future informationized operations will create new strategic balancing capabilities.

Disruptive technologies will drive continuous innovation in military theory. The military application of disruptive technologies will inevitably lead to the evolution of operational styles, requiring effective adjustments to strategic guidance,

military thinking, and operational theories to match new-quality weapons and equipment and maximize combat effectiveness. Meanwhile, disruptive technologies will exert a series of influences on military organizational structures, force composition, and structural scales.

History has repeatedly proven that whoever first achieves breakthroughs in disruptive technologies will lead future innovation and transformation. In this information age of rapid change and continuous emergence of disruptive technologies, we must place scientific and technological innovation at the core of national development, accelerate the implementation of innovation-driven development strategies, seize the strategic high ground of disruptive technologies, and forge a "sharp sword" for winning future wars. Only then can we become the designers of future warfare and the makers of game rules, truly mastering the initiative for victory and ultimately winning wars.

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Author Contributions

Bao Weimin: Drafted the full manuscript
Wang Fengwei: Designed the research approach and revised the paper
Xi Long: Designed the research framework and contributed to writing
Li Xinmin: Collected, organized, and analyzed information

Note: Figure translations are in progress. See original paper for figures.