Dual-Use Technologies

Mains: *GS III – Science and Technology*

Why in News?

Rapid advancements in emerging technologies such as nuclear science, artificial intelligence (AI), biotechnology, and space systems have expanded the scope and complexity of dual-use technologies—tools and knowledge that serve both civilian and military purposes.

What is Dual-Use Technologies?

- **Dual-use technologies** – It refer to materials, equipment, and knowledge that have legitimate civilian applications but can also be used for military or malicious purposes.
- Initially associated with nuclear technology, the concept now encompasses a broader spectrum, including:
  - Artificial Intelligence
  - Biotechnology
  - Cyber technologies
  - Additive manufacturing
  - Space-based systems
- The central challenge lies in the *"dual-use dilemma"*—balancing technological progress with the prevention of misuse.

What is the evolution of dual-use risks in modern warfare?

- **Non-Kinetic Warfare and Electronic Interference –** Recent conflicts have demonstrated the growing use of non-kinetic tools such as:
  - GPS jamming and spoofing
  - Cyber-attacks
  - Communication disruption
- These tactics can mislead navigation systems and disrupt real-time intelligence without direct physical confrontation, marking a shift in warfare strategies.
- **Commercial Space Technologies in Warfare –** Satellite systems, originally developed for civilian purposes such as:
  - Disaster management
  - Communication
  - Navigation
- **Presently used for**:
  - Military surveillance

    - Intelligence gathering
    - Operational coordination
- This blurs the line between civilian infrastructure and military assets, raising questions about legitimate targets in armed conflict.
- **Biotechnology and AI Convergence –** Advancements in biotechnology and AI have created new opportunities and risks:
- **Benefits:**
    - Vaccine development
    - Drug discovery
    - Disease surveillance
- **Risks:**
    - AI-assisted design of biological weapons
    - Genetic modification of pathogens
    - Misuse of DNA synthesis technologies
- The increasing accessibility of such technologies, including DIY biology labs, further amplifies biosecurity concerns.

- **Nuclear Technology –** Nuclear technology remains the most prominent example of dual-use:
    - **Civilian use** – Energy generation
    - **Military use** – Nuclear weapons
- **Global governance mechanisms**
    - Treaty on the Non-Proliferation of Nuclear Weapons (NPT)
    - Safeguards by the International Atomic Energy Agency (IAEA)
    - Export controls under the Nuclear Suppliers Group (NSG)
- Despite these frameworks, challenges in verification and compliance persist.

While the recent innovations such as nuclear science, artificial intelligence (AI), biotechnology, and space systems enhance human welfare, they simultaneously pose significant security, legal, and ethical challenges.

The increasing use of non-kinetic tactics, such as GPS spoofing and electronic interference in modern conflicts, highlights how civilian technologies are being repurposed for warfare.

What are the key governance challenges?

- **Technological Ambiguity**
    - Difficulty in distinguishing between civilian and military applications
    - Same infrastructure and knowledge can serve both purposes
    - **For example**, GPS used in both aviation safety and military operations
- **Rapid Technological Advancement**
    - Innovation outpaces regulatory frameworks
    - Existing treaties were designed for earlier technological contexts
    - Emerging fields like AI and synthetic biology lack comprehensive regulation
- **Weak Enforcement of Export Controls**

- Mechanisms such as:
  - Wassenaar Arrangement
  - Australia Group
- Face enforcement gaps, allowing sensitive technologies to proliferate.
- **Strategic and Geopolitical Value**
  - Dual-use technologies are linked to national power
  - States seek technological superiority
  - Lack of trust leads to arms races and escalation
- **Role of Private Sector**
  - Private companies are key developers of AI, biotech, and space technologies
  - They operate outside traditional international legal frameworks
  - Raises issues of accountability in conflict situations

What are the legal and ethical concerns?

- **Blurring of Civilian-Military Boundaries**
  - Civilian infrastructure becoming military targets
  - Challenges in applying International Humanitarian Law (IHL)
- **Inadequacy of Existing Frameworks**
- Key treaties include:
  - Biological Weapons Convention (BWC)
  - Chemical Weapons Convention (CWC)
  - Outer Space Treaty
- However, these frameworks struggle to keep pace with emerging technologies.
- **Biosecurity Risks**
  - Ambiguity in defining “sequences of concern” in DNA synthesis
  - Limitations in screening and compliance mechanisms
  - Risk of accidental or deliberate misuse

What are the governance mechanisms for dual-use technologies?

- **Preventing Malicious Development**
  - International treaties prohibiting weaponisation
  - **For example**, BWC, CWC
- **Controlling Access**
  - Export controls and licensing systems
  - Technology transfer restrictions
- **Monitoring and Compliance**
  - Inspection and verification systems
  - **For example**, IAEA safeguards

What should be done?

- **Updating Global Frameworks**
  - Expand existing treaties to include emerging technologies
  - Develop adaptive and flexible regulatory mechanisms
- **Strengthening Export Control Regimes**
  - Improve enforcement and international coordination

    - Standardise compliance mechanisms
- **Integrating Private Sector into Governance**
    - Establish accountability frameworks for companies
    - Encourage responsible innovation practices
- **Enhancing Biosecurity Measures**
    - Improve DNA synthesis screening
    - Develop clear definitions for high-risk materials
- **Promoting International Cooperation**
    - Build trust among states
    - Encourage transparency and information sharing
- **Ethical and Responsible Innovation**
    - Foster awareness among scientists and developers
    - Embed ethics into technological development

What lies ahead?

- Dual-use technologies represent a fundamental challenge in the modern technological landscape.
- While they hold immense potential for societal advancement, their misuse can have severe security implications.
- Effective governance requires a delicate balance between innovation and regulation, strengthened international cooperation, and the development of a responsible technological ecosystem.
- As technology continues to evolve, so must the frameworks that govern its use.

Reference

[The Indian Express| Dual Use Technologies]

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