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Role of science and technology in the context of international security and disarmament

Current developments in science and technology and their potential impact on international security and disarmament efforts

Report of the Secretary-General

Summary

The present report provides an overview of scientific and technological developments of relevance to weapons, means or methods of warfare and their potential impact on international security and disarmament efforts, as well as developments in relevant intergovernmental forums, pursuant to General Assembly resolution 79/23. It covers artificial intelligence and autonomy, uncrewed systems, digital technologies, biology and chemistry, space and aerospace technologies, electromagnetic technologies and materials technologies. In addition, international cooperation, including capacity-building, is addressed in the report.

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I. Introduction

1. In paragraph 4 of its resolution 79/23 on the role of science and technology in the context of international security and disarmament, the General Assembly requested the Secretary-General to submit to the Assembly at its eightieth session an updated report on current developments in science and technology and their potential impact on international security and disarmament efforts. In paragraph 48 (e) of the Pact for the Future (General Assembly resolution 79/1), Heads of State and Government requested the Secretary-General to continue to update Member States on new and emerging technologies through the report of the Secretary-General on current developments in science and technology and their potential impact on international security and disarmament efforts.

2. Science and technology contribute to human development and prosperity and are key enablers of efforts to implement the 2030 Agenda for Sustainable Development. At the same time, they may also present risks to collective efforts to maintain international peace and security.

3. There are continuing concerns that developments in science and technology of relevance to security and disarmament are outpacing the capacity of normative and governance frameworks to manage the risks. The benefits of new and emerging technologies cannot come at the expense of global security.

4. The present report provides an overview of scientific and technological developments of particular relevance to weapons, means or methods of warfare and their potential impact on international security and disarmament efforts, as well as developments in relevant intergovernmental forums.

II. Recent developments in science and technology of relevance to weapons, means or methods of warfare

A. Artificial intelligence and autonomy

5. There is no universally agreed definition of artificial intelligence, but, broadly speaking, it relates to systems designed and trained to learn, solve problems, make predictions, take decisions and perform tasks that are considered to require a level of intelligence comparable to that of a human. Artificial intelligence comprises several subfields, including machine learning, natural language processing and computer vision. Potential advantages of artificial intelligence include improvements in efficiency, automation and analytical capabilities at scale and at higher speeds.

6. Military and security applications of artificial intelligence are broad and far-reaching, including for weapon-related functions. Applications range from decision support systems for military operations to systems that support maritime security, counter-piracy efforts, counter-terrorism operations and border security operations.[1] The versatility of such systems makes them increasingly attractive to both State and non-State actors. Some States have already tested or fielded a variety of systems enabled by artificial intelligence, including uncrewed systems capable of autonomous navigation; coordinated mobility and swarming systems; systems that collect, sort and analyse intelligence, surveillance and reconnaissance data; defensive and offensive information and communications technology (ICT) systems; and simulation and training applications.

[1] Yasmin Afina, "The global kaleidoscope of military AI governance", United Nations Institute on Disarmament Research (UNIDIR), 2024.

7. Data are critical to the training, testing and use of artificial intelligence and autonomous systems. The use of high-quality data at scale can increase the performance and reliability of artificial intelligence systems that are developed, deployed and used for military and other security applications, ranging from operational and combat support to humanitarian relief efforts and civilian protection.

8. Various concerns surrounding data have been identified, including those with implications for international, regional and national peace and security.[2] Those concerns stem from, inter alia, the need to address potential harmful biases and the unreliability of data collection sensors, the limited availability of representative data across contexts, and the security of data and their protection against unauthorized access. Technical solutions aimed at addressing such concerns, including the use of synthetic and proxy data, are already being developed.

9. A whole-of-life approach to the governance of artificial intelligence in the military and other security domains is critical. Such an approach consists of identifying different points of intervention, from the design and development stages to adoption, deployment, use and eventual decommissioning.[3] Dedicated national strategy documents in support of the approach have been adopted by an increasing number of States.[4]

Relevant intergovernmental processes, bodies and instruments

10. On 12 December 2024, the General Assembly adopted its resolution 79/239 on artificial intelligence in the military domain and its implications for international peace and security. As requested in the resolution, the Secretary-General submitted a report (A/80/78), prepared on the basis of the views of Member States and observer States.

11. At the 2023 Meeting of the High Contracting Parties to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May Be Deemed to Be Excessively Injurious or to Have Indiscriminate Effects, it was decided to continue the work of the Group of Governmental Experts on Emerging Technologies in the Area of Lethal Autonomous Weapons Systems. It was also decided that the Group should further consider and formulate, by consensus, a set of elements of an instrument, without prejudging its nature, and other possible measures to address emerging technologies in the area of lethal autonomous weapon systems, taking into account the example of existing Protocols within the Convention, proposals presented by High Contracting Parties and other options related to the normative and operational framework on emerging technologies in the area of lethal autonomous weapon systems, building upon the recommendations and conclusions of the Group, and bringing in expertise on legal, military and technological aspects. The General Assembly has adopted two resolutions on lethal autonomous weapons systems (resolutions 78/241 and 79/62). On 12 and 13 May 2025, open informal negotiations were convened on the basis of the report of the Secretary-General on lethal autonomous weapons systems (A/79/88).

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[2] Yasmin Afina and Sarah Grand-Clément, “Bytes and battles: inclusion of data governance in responsible military AI”, CIGI Paper, No. 308 (Centre for International Governance Innovation, 2024).

[3] Yasmin Afina and Giacomo Persi Paoli, “Governance of artificial intelligence in the military domain: a multi-stakeholder perspective on priority areas”, UNIDIR, 2024.

[4] Yasmin Afina, “Draft guidelines for the development of a national strategy on AI in security and defence”, UNIDIR, 2024.

B. Uncrewed systems

12. Uncrewed systems can be piloted remotely, semi-autonomously or autonomously, and are employed in the aerial, ground and maritime domains. They are used by State and non-State actors alike. The use of uncrewed aerial systems in and outside conflicts is widespread; applications include military surveillance and reconnaissance, target acquisition and strike operations.[5] Their use in populated areas continues to raise concerns regarding the protection of civilians and compliance with international humanitarian law.

13. A wide range of systems exist, from high end to low end, which can be either armed or unarmed. The creation of improvised uncrewed aerial systems, either by modifying commercial systems or by manufacturing certain components (including through additive manufacturing), has become an identifiable trend, as has the conversion of uncrewed aerial systems into loitering munitions. Loitering munitions are one-way attack aerial systems that combine characteristics of uncrewed aerial systems and missiles, whereby the system itself is used as the weapon, with the ability to loiter in the air until it strikes.

14. There has also been increased development and use of uncrewed maritime systems.[6] Such systems, which can be operated either on the surface or under water, can undertake functions such as surveillance and reconnaissance, as well as conducting mine countermeasures and offensive actions.

15. Scientific and technological developments continue to enable the enhancement of uncrewed systems or components thereof. For example, State and non-State actors are experimenting with the use of hydrogen fuel cells to extend the range of such systems. Battlefield interference using uncrewed aerial systems, by means of electronic warfare, is leading to the increased integration of artificial intelligence in order to reduce the reliance on potentially vulnerable communication links (see also sect. II.A).

Relevant intergovernmental processes, bodies and instruments

16. Efforts have been made to prevent the proliferation of uncrewed aerial systems and their components to and between illegal armed groups, terrorists and other unauthorized recipients, namely through Security Council resolution 2370 (2017), the Delhi Declaration[7] and the Abu Dhabi Guiding Principles (S/2023/1035).

17. Regarding the improvement of transparency in armaments and the promotion of responsible transfers, uncrewed systems are explicitly included in category IV ("Combat aircraft and unmanned combat aerial vehicles") and category V ("Attack helicopters and rotary-wing unmanned combat aerial vehicles") of the United Nations Register of Conventional Arms. Some States Parties to the Arms Trade Treaty have included uncrewed systems in their reports submitted pursuant to the Treaty.

[5] Sarah Grand-Clément, "Armed and dangerous? A brief overview of uncrewed aerial systems: risks, impacts and avenues for action", UNIDIR, October 2024.

[6] Anabel García García, Sarah Grand-Clément and Paul Holtom, "Changing tides in maritime warfare: closing the reporting gap on uncrewed maritime systems in the United Nations Register of Conventional Arms", UNIDIR, February 2025.

[7] See www.un.org/securitycouncil/ctc/sites/www.un.org.securitycouncil.ctc/files/outcome_document_ctc_special_mtg_final_e.pdf.

C. Digital technologies

18. Digital technologies continue to revolutionize societies by serving as enablers of innovation and progress. Breakthroughs in digital technologies can also support disarmament and non-proliferation objectives by improving, for example, verification methodologies through pattern recognition, anomaly detection and rapid assessment capabilities in order to identify and monitor nuclear facilities.

19. Although digital technologies can serve both development and peace and security objectives, their misuse also poses risks. The increasing ubiquity and proliferation of digital technologies, which can be used in a broad array of applications, in both the civilian and military domains, can compound risks to international peace and security.

Information and communications technologies

20. The malicious use of ICTs garnered significant attention in 2024, with a range of documented incidents, including incidents that had an impact on essential sectors such as healthcare, banking, telecommunications and transportation.

21. Exploitation of software vulnerabilities remained an identifiable trend, as did concerns over the use of malicious software and techniques, such as phishing, man-in-the-middle attacks and distributed denial of service attacks. In 2024, significant ransomware incidents were recorded, including those affecting the healthcare sector and public transportation.[8]

22. Attention has been drawn to the use of ICTs in the context of armed conflict and the potential impact on compliance with international humanitarian law, particularly with regard to activities that disrupt or damage essential infrastructure, affect public services or target vital data, resulting in the deletion of that data or even in physical damage to civilian objects.

23. The impact of rapid advancements in artificial intelligence on ICT security has emerged as a priority issue against the backdrop of deeper integration of artificial intelligence across a range of digital technologies. In particular, States have considered the safety and security of artificial intelligence systems, as well as the data used for training machine learning and artificial intelligence models in the context of information and communications technologies security. Although artificial intelligence can be used to enhance security by increasing resilience, improving incident response times and strengthening networks, it can also transform how perpetrators approach, plan and execute intrusions.[9]

Computing technologies, including cloud and quantum technologies

24. The expansion of cloud computing has made ICTs more scalable, accessible and efficient by offering streamlined operations and reduced infrastructure costs. Cloud computing, which enables on-demand access to a shared pool of configurable computing resources, has played an increasingly crucial role in sectors such as military and defence and national critical infrastructure.[10]

25. Although cloud computing offers opportunities, such as operational resilience and enhanced information-sharing, increased dependence on the cloud environment

[8] Naveen Goud, "Top 5 ransomware attacks and data breaches of 2024", Cybersecurity Insiders, 2024.

[9] UNIDIR, "Exploring the AI-ICT security nexus", December 2024.

[10] Federico Mantellassi and Giacomo Persi Paoli, "Cloud computing and international security: risks, opportunities and governance challenges", UNIDIR, 2024.

can also pose risks. A primary risk, particularly for public cloud environments, is their expanded attack surface, which makes them appealing targets for cyberthreats, such as data breaches, distributed denial of service attacks and ransomware.[11]

26. The United Nations has declared 2025 as the International Year of Quantum Science and Technology, acknowledging the far-reaching benefits provided by the integration of quantum properties into applications, including computing.[12]

27. The launch of increasingly higher-performing quantum processors has continued at a steady pace.[13] Although quantum computers will allow for faster processing and more complex problem-solving, challenges remain. Quantum computing is expected to have serious implications for security, such as challenging current cryptographic systems, thereby potentially compromising critical infrastructure and military communications networks.[14]

28. At present, there is not a dedicated intergovernmental process to address quantum technologies in the context of international security. However, in the context of discussions on ICT security, States have noted the evolving properties and characteristics of emerging technologies, such as quantum computing, that could create new vectors and vulnerabilities.

Relevant intergovernmental processes, bodies and instruments

29. Developments in ICTs in the context of international security have been on the agenda of the General Assembly since 1998.[15] Since then, six groups of governmental experts have studied existing and potential threats in the ICT environment, made recommendations on norms, rules and principles for the responsible behaviour of States and on confidence-building and capacity-building measures, and discussed how international law applies to the use of such technologies (see A/65/201, A/68/98, A/70/174 and A/76/135). In 2018, the Open-ended Working Group on Developments in the Field of Information and Telecommunications in the Context of International Security was established by the General Assembly, which subsequently endorsed the Working Group's consensus report in 2021 (A/75/816).

30. In 2020, the open-ended working group on security of and in the use of information and communications technologies 2021–2025 was established to, inter alia, further develop the rules, norms and principles of responsible behaviour of States; to continue to study existing and potential threats in the sphere of information security and how international law applies to the use of ICTs by States; and to consider confidence-building measures and capacity-building. The working group has adopted three annual progress reports (A/77/275, A/78/265, A/79/214). It has addressed existing and potential threats in the ICT environment, including those concerning transnational critical infrastructure, including undersea cables and orbit communication networks, and challenges to information and communications technologies emanating from emerging technologies, namely artificial intelligence and quantum computing. Two significant achievements of the group in 2024 included the launch of the Global Intergovernmental Points of Contact Directory on the Use of Information and Communications Technologies in the Context of International

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[11] Ibid.

[12] See www.quantum2025.org.

[13] Wenting He, "Enabling technologies and international security: a compendium – 2023 edition", UNIDIR, 2024.

[14] UNIDIR, "2024 Innovations Dialogue: quantum technologies and their implications for international peace and security", 22 November 2024.

[15] For more information on intergovernmental deliberations on developments in the field of information and telecommunications in the context of international security, see www.un.org/disarmament/ict-security.

Security,[16] and the organization of the first global round table on ICT security capacity-building.

D. Biology and chemistry

31. The prohibition of the hostile uses of chemistry and biology is enshrined in international law through the Protocol for the Prohibition of the Use in War of Asphyxiating, Poisonous or Other Gases, and of Bacteriological Methods of Warfare, the Convention on the Prohibition of the Development, Production and Stockpiling of Bacteriological (Biological) and Toxin Weapons and on Their Destruction (Biological Weapons Convention) and the Convention on the Prohibition of the Development, Production, Stockpiling and Use of Chemical Weapons and on Their Destruction (Chemical Weapons Convention). Rapid scientific and technological advancements present new challenges that could undermine those existing disarmament and non-proliferation instruments, for example by complicating their implementation, but also present opportunities to reinforce and strengthen them.

32. The increasing convergence of biology, chemistry, artificial intelligence and quantum computing has accelerated innovation, thereby offering significant benefits in areas such as healthcare, agriculture and materials science. Practitioners also benefit from easier and cheaper access to new tools and digital facilities, including laboratories hosted in the cloud, which enable them to conduct experiments remotely.[17] Nevertheless, those developments raise potential concerns about misuse, as they could lower barriers to the development of biological and chemical weapons and lead to new vulnerabilities that threaten international security.

33. Artificial intelligence is playing an increasingly prominent role in biological modelling by improving the ability to analyse complex biological data and to design biomolecules, as well as accelerating drug discovery.[18] Biological design tools powered by artificial intelligence, including protein design tools, may, however, enable actors to develop agents that evade traditional risk mitigation measures, in particular export control measures.[19] Other applications of artificial intelligence, such as large language models, autonomous data-mining tools and generative models, may assist in acquiring materials and information relevant to biological weapons development; they may also be used to facilitate the spread of disinformation during pandemics.[20] Artificial intelligence applications may have an impact on the training and skill requirements for biological weapons development, potentially lowering the expertise threshold for development. Companies that are developing large language models have started conducting preliminary assessments of the risks that such applications could pose to international security.[21] National artificial intelligence safety institutes in some countries have conducted similar assessments, highlighting

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[16] See https://poc-ict.unoda.org.

[17] Ying-Chiang Jeffrey Lee and Barbara Del Castello, “Robust biosecurity measures should be standardized at scientific cloud labs”, RAND, 8 November 2024.

[18] Dhruv Khullar, “How A.I. teaches machines to discover drugs”, *The New Yorker*, 2 September 2024.

[19] Richard Moulange and others, “Capability-based risk assessment for AI-enabled biological tools”, Centre for Long-Term Resilience, August 2024.

[20] Sarah R. Carter and others, “The convergence of artificial intelligence and the life sciences”, NTI, 30 October2023.

[21] Christopher Mouton, Caled Lucas and Ella Guest, “The operational risks of AI in large-scale biological attacks: results of a Red-Team Study”, RAND, 25 January 2024; and Tejal Patwardhan and others, “Building an early warning system for LLM-aided biological threat creation”, OpenAI, 31 January 2024.

the need for greater attention from Member States to address the convergence of artificial intelligence and biorisks effectively.

34. Advances in materials science and quantum technology also present new opportunities and risks. Developments in the field of bioinspired nanofluidic iontronics, which can emulate some of the functionalities of the brain, such as signal processing and information transmission, are leading to advances in neuroinspired devices and brain-like computing. Nevertheless, the unintended and possible hostile applications of such technology must be carefully evaluated.[22] Quantum computing saw rapid progress in 2024. One notable example is the use of quantum algorithms for single-cell analysis.[23] Ongoing advancements and the increasing intersection of the digital and biological domains require international attention with regard to securing biodata through quantum-resistant cryptographic standards and addressing "cyberbiosecurity" concerns.[24]

35. Although the concept of mirror life (hypothetical organisms built from mirror-image molecular structures) remains largely theoretical, research in alternative biochemistries is steadily advancing the underlying science, including the synthesis of mirror-image biomolecules.[25] Scientists have already raised their concerns about mirror life research and called for a global discussion on the matter.[26]

36. Chemical sciences are also being drastically affected by their continued integration with artificial intelligence-based models and approaches. Large language models are increasingly capable of performing complicated tasks, from synthesis and retrosynthesis prediction and planning to experimental design, automated synthesis and analysis, and an integrated combination of those functions.[27] In addition, more bespoke tools and models are being developed to predict chemical structures, properties and spectral characteristics. Such advancements could strengthen verification efforts by augmenting chemical forensics approaches, for example. However, if misused, the power of these artificial intelligence-based approaches could present new challenges to preventing the development of chemical weapons.

37. Advancements in detection technologies continue to be made, allowing for lighter, field-deployable equipment with greater capacities. In particular, and partly driven by the consumer industry, wearable technologies continue to receive large investment and have the potential not only to allow for real-time monitoring of chemical exposure, but also for controlled delivery of medicines.[28] There is increasing

[22] Tingting Mei and others, "Bio-inspired two-dimensional nanofluidic ionic transistor for neuromorphic signal processing", *Angewandte Chemie International Edition*, vol. 63, No. 17 (April 2024).

[23] Alan Flurry, "Novel quantum computing algorithm enhances single-cell analysis", Phys.org, 29 November 2024; and Ping Ma and others, "Bisection Grover's search algorithm and its application in analyzing CITE-seq data", *Journal of the American Statistical Association*, vol. 120, No. 549 (2025).

[24] Noran Shafik Fouad, "Cyberbiosecurity in the new normal: cyberbio risks, pre-emptive security, and the global governance of bioinformation", *European Journal of International Security*, vol. 9, No. 4 (2024).

[25] Katarzyna P. Amadala and others, "Confronting risks of mirror life", *Science*, vol. 386, No. 6728 (December 2024).

[26] Katarzyna P. Amadala and others, *Technical Report on Mirror Bacteria: Feasibility and Risks* (2024); Amadala and others, "Confronting risks of mirrored life".

[27] Tao Song and others, "A multiagent-driven robotic AI chemist enabling autonomous chemical research on demand", *Journal of the American Chemical Society*, vol. 147, No. 15 (2025).

[28] Saskila Apoorva, Nam-Trung Nguyen and Kamalalayam Rajan Sreejith, "Recent developments and future perspectives of microfluidics and smart technologies in wearable devices", *Lab on a Chip*, No. 7 (2024).

interest in seamlessly embedding both detection technologies and potential therapeutics delivery devices into textiles and other personal protective equipment.[29]

Relevant intergovernmental processes, bodies and instruments

38. Both the Biological Weapons Convention and the Chemical Weapons Convention include provisions for review conferences every five years, at which relevant scientific and technological developments are assessed. Recognizing the pace and breadth of advances in the life sciences, the Working Group on the Strengthening of the Biological Weapons Convention is working to establish a scientific advisory mechanism to enable a better understanding of the risks and opportunities generated by advances in biology and to advise States Parties accordingly.

E. Space and aerospace technologies

Missile technologies

39. Developments in emerging technologies are enabling new and expanded functions of missile systems, which are increasingly used as long-range strike weapons in armed conflict. These developments have implications for international peace and security and efforts to ensure disarmament, the effective regulation of arms, non-proliferation and respect for humanitarian principles.

Ballistic missiles and artillery rockets

40. A growing number of States are pursuing various technological innovations that have increased the accuracy of ballistic missiles and artillery rocket systems. This has enabled the use of longer-range ballistic missiles and rockets as strike weapons, including in ongoing armed conflicts and other high-profile incidents. Some non-State actors have also been able to acquire and use ballistic missiles and rockets.

41. These technological innovations have also enabled the development and testing of large-calibre artillery rocket systems that may blur distinctions between artillery rockets and ballistic missiles capable of delivering a nuclear weapon. That trend has continued to pose a challenge to regimes designed to curb the proliferation of ballistic missiles capable of delivering nuclear weapons.

42. These developments have led States to develop and acquire missile defences, some types of which can exacerbate tensions and increase instability, in the light of different views on the relationship between offensive and defensive weapon systems.

Hypersonic glide vehicles

43. Some States have continued to develop and deploy missiles equipped with warheads that can glide and manoeuvre at hypersonic speeds over long distances within the atmosphere, sustained by aerodynamic lift. Hypersonic glide vehicles could be capable of avoiding mid-course missile defences and challenging terminal defences, owing to their manoeuvrability or because they fly below the horizon for terminal defence radars at distances farther from their targets. The use of these systems has not yet been observed in armed conflict, and the strategic implications are not fully understood. Nonetheless, the first known deployment in 2019 of a

[29] Musaddaq Azeem and others, “Design and development of textile-based wearable sensors for real-time biomedical monitoring; a review”, *The Journal of the Textile Institute*, vol. 116, No. 1 (2025).

hypersonic glide vehicle on an intercontinental-range ballistic missile sparked concerns over a new strategic arms competition.

Powered hypersonic vehicles

44. States and private companies have continued to test supersonic combustion ramjet (scramjet) engines designed, at least in part, to render hypersonic cruise missiles more capable of evading air defence and anti-missile systems. Such systems in active development may be capable of being launched by ground-, sea- and aircraft-based boosters and armed with conventional or possibly nuclear warheads.

Anti-missile and terrestrial anti-satellite systems

45. More States are developing and acquiring anti-missile systems, including in direct response to their use in ongoing armed conflicts. Surface-to-air systems that intercept their target within the lower atmosphere are increasingly common. The widespread deployment of these systems has resulted in greater acquisition and use of inexpensive self-detonating drones, including in attempts to overcome such defences.

46. States have continued to develop, test and deploy anti-missile systems designed to strike missiles outside the atmosphere in the mid-course phase of flight. The more capable systems have a de facto ability to strike satellites in low Earth orbit. States also continue to deploy terrestrial missiles that have reportedly been developed specifically to strike satellites in low Earth and geostationary orbit. A State has also announced plans to develop strategic space-based anti-missile systems.

Relevant intergovernmental processes, bodies and instruments

47. The General Assembly established three panels of governmental experts on the issue of missiles in all its aspects between 2001 and 2008 (see A/57/229, A/61/168 and A/63/176). Although the issue of missiles remains on the agenda of the First Committee, there has been no resolution on the topic since the adoption of resolution 63/55.

48. There are two intergovernmental arrangements comprised of voluntary measures dedicated to missile technology. The Missile Technology Control Regime was established in 1987 with the aim of limiting the spread of ballistic missiles and other uncrewed delivery vehicles capable of delivering weapons of mass destruction. It currently has 35 members. The Hague Code of Conduct against Ballistic Missile Proliferation, adopted in 2002, includes politically binding commitments by States to exercise maximum restraint in developing, testing and deploying ballistic missiles and to uphold transparency measures regarding policies on, and launches of, ballistic missiles and space launch vehicles. A total of 145 States subscribe to the Code.

49. The issue of terrestrial anti-satellite weapons has been raised in various United Nations bodies concerned with outer space security, including most recently in the Group of Governmental Experts on Further Practical Measures for the Prevention of an Arms Race in Outer Space. The General Assembly, in its resolution 77/41, called upon all States to commit not to conduct destructive direct-ascent anti-satellite missile tests.

Space-based technologies

50. Military forces are increasingly dependent on space-based technologies for tasks such as early warning, navigation, surveillance, targeting and communications. Space systems, including satellites are increasingly exposed to various counter-space threats.

Capabilities that enable rendezvous and proximity operations

51. Many emerging capabilities entail rendezvous and proximity operations, involving satellites that manoeuvre closely to a target satellite in order to operate nearby or to make physical contact. States and commercial actors have continued to develop and deploy systems that can provide other services to active satellites in orbit, including inspection, repair, augmentation and relocation. Commercial actors have continued to launch technology demonstration satellites in support of the development of active debris removal capabilities. Those actors continue to study various means of removal, including the use of robotic arms, nets, harpoons, magnets and adhesives, as well as the possible use of space-based lasers to destroy relatively small-scale space debris.[30] In parallel, a number of States have continued to launch and operate satellites designed to visually inspect the satellites of others. These have generally involved systems operated by military or national intelligence agencies and have approached both commercial and other military satellites. Although all these capabilities have beneficial applications, they could also be used for hostile acts.

Space situational awareness

52. Several States and an increasing number of commercial actors are developing and expanding space situational awareness capabilities by using both terrestrial and space-based systems, including radars and optical telescopes. Such capabilities enable States and other entities to monitor, track and characterize the behaviour of space objects, which can both serve national security objectives and support the monitoring and verification of future arms control arrangements.

Other space-based capabilities

53. States and commercial companies have continued to study and test space-based lasers for means of communications. While lasers with low power can potentially dazzle or temporarily blind optical sensors, higher-power lasers can damage certain sensitive components of satellites or other space-based systems.

54. There have been allegations that a State has tested the deployment of a space object in a high radiation environment, possibly related to stationing nuclear weapons in orbit.

Relevant intergovernmental processes, bodies and instruments

55. International law prohibits the placement and installation of nuclear weapons or any other weapons of mass destruction in orbit or on celestial bodies or the stationing of such weapons in outer space in any other manner; the establishment of military bases, installations and fortifications, the testing of any type of weapons and the conduct of military manoeuvres on celestial bodies; and any nuclear weapon test explosion, or any other nuclear explosion, in outer space.[31] Furthermore, the General Assembly, in its resolution 79/18, affirmed the obligation of States to comply with the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies.

56. The prevention of an arms race in outer space has been on the agenda of the Conference on Disarmament since 1982.

[30] See www.nasaspaceflight.com/2024/02/adrasj-space-debris.

[31] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, art. IV; and Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water, art. I (1) (a).

57. Several workstreams initiated under the auspices of disarmament organs of the General Assembly have achieved agreed outcomes, including on transparency and confidence-building measures in outer space activities in 2013 (A/68/189), and recommendations on the practical implementation of confidence-building measures in outer space activities in 2023 (A/78/42) and on substantial elements of an international legally binding instrument on the prevention of an arms race in outer space in 2024 (A/79/364). Other related agreed outcomes achieved under the auspices of the General Assembly have included the Guidelines for the Long-term Sustainability of Outer Space Activities (A/AC.105/C.1/L.366).

58. By its decision 79/512, the General Assembly established the open-ended working group on the prevention of an arms race in outer space in all its aspects for the period 2024–2028, which replaced the working groups established pursuant to Assembly resolutions 78/20 and 78/238.

F. Electromagnetic technologies

59. A variety of weapon technologies exist or are under development that use electromagnetic energy to achieve their primary mode of effect or to propel projectiles. These weapons can be divided into three general categories: (a) electronic warfare capabilities, which deny, impede or destroy an adversary's ability to access the electromagnetic spectrum; (b) directed-energy weapons, which are electromagnetic systems capable of focusing radiated energy on a target, resulting in physical damage; and (c) electromagnetically propelled weapons, which use electromagnetic energy to accelerate a projectile to a high velocity.

60. Modern military systems frequently rely on sensors, guidance systems and communications that use electromagnetic signals. Electronic warfare systems exploit that reliance through jamming, disrupting or spoofing signals and can be used to attack electromagnetically dependent military assets or safeguard one's own assets. Several States are developing ground-based electronic warfare capabilities to disrupt space-based services.

61. Convergence with advances in artificial intelligence is further driving developments in the field of electromagnetic technologies. For example, cognitive electronic warfare leverages artificial intelligence and machine learning to sense, analyse and adapt to the electromagnetic environment autonomously and in real time. Such developments, as well as the increased use of electronic warfare systems, are driving innovation in electronic warfare-resistant systems across critical domains, such as navigation, communications and sensing. Moreover, electronic warfare systems are increasingly commercially available, raising concerns over their proliferation.

62. Directed-energy weapons include high-energy lasers, high-power microwaves, millimetre waves and particle beams. States have been increasingly testing directed-energy weapons as countermeasures against uncrewed aerial vehicles (including "drone swarms"), rockets, missiles and incoming munitions. Such weapons range in size, from small, portable systems, to those mounted on naval vessels. Recently, some States have also announced that they have moved beyond testing and are deploying their first combat-capable directed-energy systems.

63. Electromagnetically propelled weapons, such as rail or coil guns, could be capable of launching projectiles to greater distances and at greater speeds than chemical propellants, as well as at lower costs. Such weapons are primarily considered for anti-access/area denial and naval defence roles. However, while prototypes have been test fired, technical barriers remain, including the requirement

for a large power supply and sufficiently robust components, leading States to reduce their investments in this area.

Relevant intergovernmental processes, bodies and instruments

64. Electronic warfare capabilities and directed-energy weapons were discussed by the Group of Governmental Experts on Further Practical Measures for the Prevention of an Arms Race in Outer Space (see A/74/77). The current views of Member States can be found in recent reports of the Secretary-General on the disarmament aspects of outer space, including documents A/76/77 and A/77/80. The open-ended working group on reducing space threats through norms, rules and principles of responsible behaviours discussed issues related to electronic warfare in the context of its mandate, as reflected in the Chair's summary (A/AC.294/2023/WP.22).

G. Materials technologies

65. Innovations in materials science may lead to various implications for peace and security, such as by enabling significant progress in miniaturization, weight reduction, energy efficiency, enhanced protection and physical resistance, and increased stealth capabilities. These properties are key enabling factors in the development of modern conventional platforms, as well as weapons systems and their parts and components.

66. Additive manufacturing – or 3D printing – is a type of automated manufacturing technique that can be used to build objects of virtually any shape or form, based on a digital build file, by depositing and fusing layers of material.[32] Additive manufacturing enables the decentralized production of an increasing number of parts and components, creating challenges for the governance and monitoring of supply chains and export controls. That, combined with a wealth of open-source knowledge, has further lowered the barriers for State and non-State actors to build a wide range of complex components. For example, 3D-printed automatic firearms have become increasingly prevalent as a cheap and reliable alternative to conventional firearms.[33] Additive manufacturing techniques are also proving capable of producing nuclear-related hardware, making it easier to obtain the components and machinery necessary to establish nuclear enrichment capabilities.[34]

67. Developments in nanotechnology make it easier to produce, transport and deliver chemical and biological agents, potentially hindering non-proliferation efforts. However, they are also enabling the deployment of on-site detection platforms for chemical and biological agents, for subsequent confirmation in laboratories. These portable devices may also be integrated into remotely operated vehicles.[35] Recently, artificial intelligence has allowed for the development of novel nanomaterials, accelerating their design and enabling precise control over material properties.[36]

68. Modular weapons are composed of multiple components that can be reconfigured, which presents challenges to the requirement in the International

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[32] See www.sipri.org/research/armament-and-disarmament/dual-use-and-arms-trade-control/emerging-military-and-security-technologies/additive-manufacturing.

[33] Stefan Schaufelbühl and others, "The emergence of 3D-printed firearms: an analysis of media and law enforcement reports", *Forensic Science International*, vol. 8 (2024).

[34] Ivan Silunianov, "Printers of mass destruction: seeking pathways to curb the threat of additive manufacturing", Centre for Arms Control and Non-Proliferation, 5 August 2024.

[35] E. Meyle and M.A. Wilson, "Emerging technologies in chemical threat reduction", *American Journal of Bioterrorism, Biosecurity and Biodefense*, vol. 6, No. 1 (2025).

[36] Wenting He, "Enabling technologies and international security: a compendium – 2024 edition", UNIDIR, p. 12.

Tracing Instrument to Enable States to Identify and Trace, in a Timely and Reliable Manner, Illicit Small Arms and Light Weapons that a unique marking be included on an essential or structural component of a weapon. The use of polymer plastics in weapons manufacture has raised concerns, as markings on such material are more vulnerable to erasure and alteration than traditional materials, such as steel.

Relevant intergovernmental processes, bodies and instruments

69. At the Fourth United Nations Conference to Review Progress Made in the Implementation of the Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All Its Aspects, States agreed to ensure the effectiveness of marking and record-keeping, regardless of the materials or manufacturing methods used (see A/CONF.192/2024/RC/3). States also agreed to exchange experiences, lessons learned, good practices and relevant guidance relating to efforts to address the illicit manufacture of small arms and light weapons, including the use of additive manufacture technologies, such as 3D printing.

70. By its resolution 79/40, the General Assembly decided that an open-ended technical expert group to address developments in small arms and light weapons manufacturing, technology and design would be established following the Fourth Review Conference. The open-ended technical expert group will meet for the first time during the Biennial Meeting of States under the Programme of Action in 2026.

III. International cooperation, including capacity-building

71. International cooperation is essential to realize the full potential of developments in science and technology, while also mitigating potential risks to peace and security. States recognize that such cooperation, including capacity-building, can support decisive steps to bridge the growing technological divide within and between countries and accelerate progress towards the 2030 Agenda for Sustainable Development. In addition to benefiting development objectives, international cooperation can support the implementation of and adherence to disarmament, non-proliferation and arms control agreements and frameworks, as well as supporting States' ability to actively and meaningfully engage in related intergovernmental discussions.

72. While closing technological divides requires building foundational technical capacities in areas such as computing power, evaluation mechanisms and data collection, other structural aspects of capacity-building are also essential. Those aspects include workforce development and the preparation of national policies, strategies and legislation. There has also been a growing interest in fellowship and training programmes focused on diplomatic and policy-related matters, including in the areas of ICT security and artificial intelligence.

73. In that connection, the various types of capacity-building in the context of international security can be categorized as follows:

(a) Technical and infrastructural capacities;

(b) Development of national policies, strategies and legislation;

(c) Human resources, knowledge and skills transfer;

(d) Support for multilateral engagement and policymaking, including in governance discussions.

74. The importance of international cooperation has been raised in the context of several intergovernmental processes related to developments in science and

technology, including those under the auspices of the United Nations and those addressing specific types of technology. Several such processes are outlined below, demonstrating the cross-cutting nature of international cooperation and its high relevance to discussions on developments in science and technology and their potential implications for international peace and security.

Closing digital divides

75. In September 2024, the General Assembly adopted the Global Digital Compact, annexed to the Pact for the Future, in which States pledged to harness the benefits of existing, new and emerging technologies and mitigate the associated risks through effective, inclusive and equitable governance at all levels (resolution 79/1).

76. One of the five key objectives of the Global Digital Compact is to close all digital divides and accelerate progress across the Sustainable Development Goals. To achieve that objective, several actions are outlined, namely: to connect all people, schools and hospitals to the Internet; to make digital technologies more accessible and affordable to all people, including in diverse languages and formats; to increase investment in digital public goods and digital public infrastructure; and to support innovation, including among women and young people, and small and medium-sized enterprises.

77. Underpinning those actions is the need for international cooperation, including by building digital skills and capacity, investing in digital public goods, such as open-source software and open artificial intelligence models, and supporting universal Internet connectivity for all people. Recognizing the importance of artificial intelligence capacity-building, in particular, States requested the Secretary-General, through the Global Digital Compact, to develop innovative voluntary financing options for artificial intelligence capacity-building that take into account the recommendations of the High-level Advisory Body on Artificial Intelligence for a global fund on artificial intelligence. International cooperation and capacity-building should also be leveraged to promote the safety and security of digital technologies, thereby minimizing the risk of misuse and the introduction of new digital vulnerabilities that could be exploited by malicious actors.

Relevant intergovernmental processes, bodies and instruments

Artificial intelligence in the military domain

78. By its resolution 79/239, the General Assembly recognized the need to narrow the existing artificial intelligence divides in societies and economies between and within developed and developing countries, with specific consideration given to the needs, priorities and conditions of developing countries. It resolved to bridge the divides between countries with regard to responsible artificial intelligence in the military domain and called upon States to take action to cooperate on a voluntary basis in providing assistance to and sharing knowledge with developing countries by exchanging good practices and lessons learned on ensuring responsible application of artificial intelligence in the military domain.

Information and communications technology security

79. Under the open-ended working group on security of and in the use of information and communications technologies, States have engaged in cross-cutting discussions on the topic of capacity-building. Capacity-building is one of the core points of discussion of the working group, and States have made progress on a range of initiatives, including the convening of a global round table on ICT security capacity-building in May 2024.

80. States have continued to promote the mainstreaming of the principles of capacity-building in relation to ICT, as contained in annex C to document A/78/265 and first elaborated in the final report of the Open-ended Working Group on Developments in the Field of Information and Telecommunications in the Context of International Security (A/75/816, annex I, para. 56). By endorsing those principles, States have concluded that capacity-building should be sustainable, evidence-based, politically neutral, transparent, accountable and without conditions.

Biology and chemistry

81. Under article X of the Biological Weapons Convention, States Parties "in a position to do so shall also co-operate in contributing individually or together with other States or international organisations to the further development and application of scientific discoveries in the field of bacteriology (biology) for the prevention of disease, or for other peaceful purposes". In that connection, States Parties are considering the establishment of a mechanism to facilitate the full implementation of international cooperation and assistance under article X.

82. Under article XI of the Convention on Chemical Weapons, States Parties are encouraged to cooperate internationally in the field of chemistry and to exchange scientific and technical information relating to the whole chemical life cycle for purposes not prohibited under the Convention. The Organisation for the Prohibition of Chemical Weapons supports several programmes focused on the exchange of information, equipment and chemicals and provides expert support to build and maintain the technical capabilities of analytical chemistry laboratories globally. In 2023, the Organisation opened its Centre for Chemistry and Technology, which serves to create synergies in knowledge-sharing, scientific and technical collaboration and capacity-building activities.

Outer space security

83. The Group of Governmental Experts on Transparency and Confidence-building Measures in Outer Space Activities has recognized the benefits of international cooperation and capacity-building in the peaceful uses of outer space, as well as the adoption of a policy aimed at promoting the open dissemination of satellite data (A/68/189, paras. 49 to 56).

84. In its 2023 report, the United Nations Disarmament Commission included a number of recommendations to address international cooperation (A/78/42, annex, para. 15 (f)). In its 2024 report, the Group of Governmental Experts on Further Practical Measures for the Prevention of an Arms Race in Outer Space considered possible substantial elements of international cooperation that could be taken into account in further measures and appropriate international negotiations, including for a legally binding instrument on the prevention of an arms race in outer space (A/79/364, para. 72).

Small arms and light weapons

85. Under the Programme of Action to Prevent, Combat and Eradicate the Illicit Trade in Small Arms and Light Weapons in All Its Aspects, States have consistently tackled the issue of international cooperation and assistance. The newly established open-ended technical expert group to address developments in small arms and light weapons manufacturing, technology and design will meet for the first time in 2026 to, inter alia, identify and examine specific international cooperation and assistance measures aimed at building the capacities of States, including by bridging technology gaps and providing technical assistance to strengthen national capabilities.

IV. Conclusions and recommendations

86. In the Pact for the Future, States recognized that rapid technological change presented opportunities and risks to collective efforts to maintain international peace and security, and committed to be guided in their approach to address those risks by international law, including the Charter of the United Nations (General Assembly resolution 79/1, para.48). Member States are encouraged to take concrete measures to that end.

87. In that connection, United Nations entities will continue to support States' efforts to address emerging challenges that could impact international peace and security, as well as those with implications for human rights, humanitarian norms and principles, or other purposes and objectives of the Organization.

88. Member States have considered the impact of specific technologies on international peace and security in a variety of forums. However, synergies and convergences between technologies have not received the same level of attention. It is recommended that Member States identify multilateral forums to discuss synergies between the technologies considered in the present report.

89. It is essential that multi-stakeholder approaches to relevant discussions are strengthened in the light of the diverse set of actors driving innovations in science and technology. It is recommended that United Nations bodies and entities continue to encourage multi-stakeholder, geographically equitable and gender-balanced engagement in their work, including by academia, industry and other private sector actors, through formal and informal platforms.

90. International cooperation and capacity-building efforts will remain critical to seizing the opportunities associated with new and emerging technologies, while also addressing risks posed by their misuse. Such efforts should be aimed at bridging digital divide and ensuring that all States can safely and securely seize the benefits of such technologies.

91. Member States are encouraged to continue to seek ways of integrating reviews of developments in science and technology in their work within all relevant United Nations disarmament bodies, including through processes for reviewing the operation of disarmament treaties. This could entail the development of dedicated science and technology review mechanisms, when relevant, to inform intergovernmental discussions.