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# NEWSPACE AND THE COMMERCIALIZATION OF THE SPACE INDUSTRY

## Challenges for the Missile Technology Control Regime

KOLJA BROCKMANN AND NIVEDITA RAJU

**STOCKHOLM INTERNATIONAL**
**PEACE RESEARCH INSTITUTE**

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**STOCKHOLM INTERNATIONAL**
**PEACE RESEARCH INSTITUTE**

Signalistgatan 9
SE-169 70 Solna, Sweden
Telephone: +46 8 655 97 00
Email: sipri@sipri.org
Internet: www.sipri.org

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Kolja Brockmann and Nivedita Raju, October 2022

## Summary

NewSpace is not only changing the nature of the space industry, it is exacerbating existing missile proliferation risks and posing challenges for the effective implementation of export controls. It therefore requires a coordinated response by the Missile Technology Control Regime (MTCR).

NewSpace broadly describes the rise of innovative approaches and commercialization in the space industry. New entrepreneurial space companies and start-ups of all sizes are especially likely to identify with NewSpace. Many of them adopt lean organizational structures and flat hierarchies—typically associated with Internet start-up companies—and largely rely on venture capital and other private funding sources. They are breaking with the traditional approach of established aerospace and defence companies, which largely work as contractors for national or regional space agencies.

The emergence of NewSpace is fuelling the growth and spread of the global commercial space sector, resulting in many more actors gaining access to dual-use space and space launch technologies. Most significantly, technological advances have enabled much smaller and lighter satellites, which have spurred demand for small and micro launchers. Many of the small and micro launchers currently in development pose proliferation concerns as they may more closely resemble ballistic missiles than previous space launch vehicles (SLVs). The growth and development of the commercial space sector also broadens the range of possible missile proliferation scenarios. These include procurement of SLV technology from commercial suppliers; camouflaging ballistic missile programmes using commercial space industry activities; and building commercial SLV programmes as a hedge. States should therefore strengthen missile-related export controls and complementary instruments. This is necessary to address the growing commercial availability of SLVs and other sensitive technology. In addition, there are gaps in awareness and understanding of export controls among NewSpace companies, and possible vulnerabilities to illicit procurement attempts linked to their commercial activities and funding models.

The MTCR is the main multilateral export control regime through which states seek to prevent the proliferation of missiles and uncrewed aerial vehicles (UAVs). The MTCR equipment, software and technology annex already provides comprehensive control list coverage of dual-use missile and SLV technology. While the MTCR's controls aim not to impede national space programmes, they include no general exception for transfers of dual-use goods to such programmes and only limited technical exceptions for specific items. The dual-use list of the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-use Goods and Technologies also covers a range of space technologies, including SLVs. Controls on transfers of technology and technical assistance and catch-all controls are particularly important tools to control transfers of sensitive design data and relevant aspects of emerging technologies such as additive manufacturing. Other instruments that could complement and help strengthen the effectiveness of export controls established by the MTCR and the Wassenaar Arrangement are national mechanisms for screening foreign direct investment (FDI) and bilateral technology safeguards agreements for cooperative use of space launch facilities.

Companies, research institutes, universities and other entities participating in the NewSpace ecosystem face a complex, yet often incomplete and confusing regulatory environment. The patchwork of space regulations adopted varies significantly between states. Space regulators, export licencing authorities and other relevant national or regional authorities should better coordinate to improve mutual awareness and

engagement with industry. This should include providing more clarity on compliance obligations and licencing procedures to those in the NewSpace industry. Industry associations and forums can play a key role in facilitating outreach and awareness raising by governments and the exchange of experiences and good practices among NewSpace companies.

Russia's renewed invasion of Ukraine—during Russia's period as chair of the MTCR in 2021/22—exacerbates the difficulty of finding consensus on policy decisions in the MTCR. However, as the technical policy discussions continue largely unaffected, the MTCR is likely to continue to play a central role in addressing missile non-proliferation risks, including those posed by NewSpace. The MTCR partners should therefore continue to coordinate export control policies directed at the NewSpace industry and should maintain the MTCR annex, including amendments where necessary, to address developments in space technologies. They should further share good practices on outreach and engagement with the space industry and NewSpace community and engage in dialogue among MTCR partners, and outreach to adherents and non-partners about the proliferation risks posed by NewSpace. They should also develop appropriate guidance materials for states and industry. Inter-regime dialogue with the Wassenaar Arrangement should inform the production of such materials. Finally, the MTCR should engage with the Hague Code of Conduct against Ballistic Missile Proliferation (HCOC) on complementary transparency, confidence-building and safeguards measures for national space activities.

# Abbreviations

| | |
|---|---|
| CBN | Chemical, biological and nuclear (weapons) |
| EU | European Union |
| FDI | Foreign direct investment |
| HCOC | Hague Code of Conduct against Ballistic Missile Proliferation |
| ICBM | Intercontinental ballistic missile |
| ICP | Internal compliance programme |
| LEEM | Licensing and enforcement experts meeting |
| MTCR | Missile Technology Control Regime |
| NASA | National Aeronautics and Space Administration (United States) |
| SLV | Space launch vehicle |
| UAV | Uncrewed aerial vehicle |

# 1. Introduction

The past decade has seen the rapid emergence of a new private and largely commercial space industry across spacefaring states and beyond. The commercialization and expansion of what were once highly centralized national or regional industries clustered around state-run space programmes has started to create a more complex and competitive international market.[1] The term NewSpace broadly describes the rise of innovative approaches, commercialization and new business practices in the space industry. NewSpace companies embrace innovations in novel and emerging technologies and often have a greater willingness to adopt them while bearing the associated higher risk. The changing nature of the space industry—particularly through its NewSpace entrants—is resulting in changes in business practices, new funding sources and capitalization models, and gaps in awareness and understanding of export controls that are increasing the risk of missile technology proliferation.

These characteristics and trends in the NewSpace industry mean that it poses particular export control and compliance challenges. For example, NewSpace companies develop, test, produce, use and market a range of dual-use technologies, including small and micro launchers for small satellites, that could be used for chemical, biological and nuclear (CBN) weapons delivery systems. Space launch vehicle (SLV) technology has always been similar to the technologies required for the development, testing, production and use of ballistic missiles. While the technical and operational requirements of ballistic missiles differ, some of them significantly, advances in the field of small and micro launchers are moving some new SLVs technologically closer to medium- and intermediate-range ballistic missiles.[2] In addition, NewSpace companies face significant competition and often need to look for customers and investors beyond national or regional space programmes. NewSpace has created a rapidly growing industry that, on the one hand, needs to be aware of and comply with export controls and, on the other hand, challenges existing export controls by seeking innovative approaches that increase the availability and accessibility of sensitive dual-use missile technologies.

Export controls are regulatory tools that aim to prevent the proliferation of CBN weapons and their delivery systems—particularly missiles—and destabilizing accumulations of conventional weapons. These controls take the form of licencing requirements on the trade in arms and dual-use goods and technology (i.e. goods, software and technology that could be used for civilian and military end uses) and the provision of related technical assistance. The Missile Technology Control Regime (MTCR) is the most relevant multilateral export control regime through which supplier states seek to coordinate their export controls to prevent the proliferation of missiles and uncrewed aerial vehicles (UAVs) capable of delivering CBN weapons (see box 1.1).[3] The MTCR has 35 participating states, referred to as 'partners', that set common guidelines for exports of missile technology. Three other states have officially declared their voluntary adherence to the guidelines. The MTCR maintains the equipment, software

[1] Brukardt, R. et al., *The Role of Space in Driving Sustainability, Security, and Development on Earth* (McKinsey & Company: New York, May 2022).

[2] Schmucker, R. H. and Schiller, M., *Raketenbedrohung 2.0: Technische und politische Grundlagen* [Missile threat 2.0: Technical and political basics] (E.S. Mittler & Sohn: Hamburg, 2015), pp. 330–33; and Maitre, E. and Moreau-Brillatz, S., 'The Hague Code of Conduct and space', HCoC Research Papers no. 10, Fondation pour la Recherche Stratégique, Mar. 2022, pp. 23–25.

[3] MTCR, 'Objectives of the MTCR', [n.d.]. The MTCR refers to CBN weapons as weapons of mass destruction (WMD). However, the term WMD lacks a generally recognized definition and, even if used to describe CBN weapons, implies their use for 'mass destruction', which is often less appropriate for describing the capabilities of many chemical or biological weapons. This paper therefore refers instead to CBN weapons or, where appropriate, nuclear weapons.

**Box 1.1.** The Missile Technology Control Regime

The Missile Technology Control Regime (MTCR) is an informal political understanding among a group of 35 supplier states that aims to limit the proliferation of missiles and other uncrewed delivery systems capable of delivering chemical, biological or nuclear (CBN) weapons (referred to by the MTCR as 'weapons of mass destruction').[a] A further three states adhere voluntarily to the MTCR's restriction. It was established by the Group of Seven (G7) states in 1987, originally as an instrument to help prevent the proliferation of nuclear weapons by controlling the missiles capable of delivering them. The scope of the MTCR has since expanded to include ballistic and cruise missiles capable of delivering any CBN weapon.

Through the MTCR, the 35 MTCR partners harmonize their export controls by following the MTCR guidelines for sensitive missile-relevant transfers and by maintaining a control list (the MTCR equipment, software and technology annex) that covers missiles and certain uncrewed aerial vehicles (UAVs) and relevant dual-use goods and technologies. The annex divides the items it covers into two categories.

*Category I* includes any complete missile or UAV 'capable of delivering at least a 500 kg "payload" to a "range" of at least 300 km' (e.g. ballistic missiles, space launch vehicles, sounding rockets, cruise missiles and reconnaissance drones); complete major subsystems (e.g. rocket stages and engines, guidance systems and re-entry vehicles); related software and technology; and specially designed production facilities.[b] For all category I items, the partners commit to exercising an 'unconditional strong presumption of denial', meaning that no licences for export of such items should be issued under all but the most exceptional circumstances.[c] The export of category I production facilities is prohibited without exception.

*Category II* includes dual-use missile- and UAV-related components and complete missile and UAV systems with a range of at least 300 km, regardless of their payload capability.[d] Exports of such systems destined for any CBN weapon-delivery end use are also subject to a strong presumption of denial.[e] All other exports of category II items are subject to licensing procedures and are to be assessed with consideration of the criteria outlined in the guidelines.

The MTCR takes decisions (e.g. on admitting new partners or making amendments to the annex) by consensus. These decisions are politically, rather than legally, binding. The main decision-making body of the MTCR is the plenary, which convenes every year, usually in October, and is hosted by the annually rotating chair. The MTCR has several subsidiary bodies that cover different topics and operational functions: the technical experts meeting (TEM), the information-exchange meeting (IEM), the licensing and enforcement experts meeting (LEEM), regular point of contact (POC) meetings, and occasional reinforced point of contact (RPOC) meetings.

[a] MTCR, 'Objectives of the MTCR', [n.d.].
[b] MTCR, 'Equipment, software and technology annex', MTCR/TEM/2021/Annex, 8 Oct. 2021, items 1–2.
[c] MTCR, 'Frequently asked questions (FAQs)', [n.d.].
[d] MTCR (note b), items 3–20.
[e] MTCR (note c).

and technology annex, which is a control list of complete missile systems, other uncrewed delivery systems and relevant dual-use items.[4]

Russia's renewed invasion of Ukraine—during Russia's period as chair of the MTCR in 2021/22—exacerbates the difficulty of finding consensus on policy decisions in the MTCR. However, as the technical policy discussions continue largely unaffected, the MTCR continues to play a central role in addressing the challenges posed by NewSpace, including as a forum where the partners can coordinate their approaches to industry outreach and awareness raising, good practice, and the development of guidance material. It can also act as a forum for discussions that would support other complementary governance efforts.

The MTCR is not the only instrument through which states coordinate export controls on missiles and missile technology: the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-use Goods and Technologies also serves this function. In contrast to the MTCR, the Wassenaar Arrangement aims to prevent transfers from contributing to 'destabilising accumulations' of conventional weapons and dual-use technologies that would endanger international and regional security and stability.[5] Wassenaar Arrangement export controls do not seek to prevent the proliferation of missiles and other CBN weapon-related delivery systems, and there is no

[4] MTCR, 'Equipment, software and technology annex', MTCR/TEM/2021/Annex, 8 Oct. 2021.
[5] Wassenaar Arrangement, 'Initial elements', *Public Documents*, vol. I, *Founding Documents* (Wassenaar Arrangement: Vienna, Dec. 2019), p. 4.

presumption of denial of transfers of complete missiles and subsystems.[6] The Hague Code of Conduct against Ballistic Missile Proliferation (HCOC) is a related instrument that contributes to ballistic missile non-proliferation. The HCOC is a transparency and confidence-building instrument concerned with the ballistic missile and SLV programmes and launch activities of the 143 states that currently subscribe to the code.[7] These two instruments are complemented by a range of national regulations and policies relating to controls on and screening mechanisms for foreign investments.

To date, there has been a distinct lack of research and analysis of the impact of the development of the NewSpace industry and related trends on missile proliferation risks, export controls and related regulatory tools.[8] While there have been discussions about proliferation risks resulting from the growing commercialization of the space industry in the export control and non-proliferation community and about the challenges posed by export controls and their impact on the NewSpace industry, these separate discussions have rarely been linked. This report seeks to identify which developments and trends tied to the emergence of the NewSpace industry pose possible missile proliferation risks. It also looks at the challenges these trends present for the existing system of export controls and focuses on the particular role that can be played by the MTCR. The report then identifies ways of strengthening the implementation of export controls and related policy instruments through the MTCR and national measures, while minimizing adverse consequences for competitiveness, in order to prevent commercial space industry activities contributing to programmes for missiles and other CBN delivery systems.

Chapter 2 of this report explores the NewSpace industry as a possible source of proliferation risk. It outlines the features and spread of NewSpace, the key stakeholders involved, the dual-use dilemma of space launch technology, and the possible proliferation scenarios involving the commercial space sector. Chapter 3 discusses the content and the application to the space sector of the MTCR guidelines and control lists, the Wassenaar Arrangement export controls, foreign direct investment (FDI) screening mechanisms, and technology safeguards agreements. Chapter 4 discusses the regulatory environment for the NewSpace industry and the difficulties of outreach to and awareness raising in the industry. Chapter 5 then discusses the role of the MTCR in addressing the challenges posed to export controls by NewSpace and the commercialization of the global space sector. It develops specific recommendations to help reduce proliferation risks and safeguard commercial space activities.

[6] Wassenaar Arrangement, 'About us', 23 Dec. 2021.

[7] Hague Code of Conduct against Ballistic Missile Proliferation, 'Description of HCoC', Oct. 2020; and Barré, S. and Maitre, E., 'The HCoC and space', *HCoC Issue Brief*, Sep. 2021.

[8] An exception is recently published research by the Fondation pour la Recherche Stratégique (FRS) on NewSpace as a missile proliferation risk in the specific context of the HCOC. See Barré and Maitre (note 7); and Maitre and Moreau-Brillatz (note 2).

# 2. The NewSpace industry and missile proliferation risks

## NewSpace and commercialization of the space industry

The term 'NewSpace' is broadly associated with the rise of innovation and commercialization in the space industry and with new approaches and business practices in the space sector. While 'NewSpace' is widely used to refer to companies in the space sector, there is no consensus on its definition. Essentially, it refers to new entrepreneurial businesses or start-ups in the global space sector, as well as the shifting dynamics of the sector's commercialization and the new business practices that these companies embrace.[9] Some have thus defined NewSpace as a process of evolution (rather than an industry) whereby space activities are becoming commercialized and are departing from traditional state-centric models.[10] Many of the new entrants to the space industry seek to challenge traditional approaches to the development, production and operation of space systems and the space sector—which are often regarded as slow and expensive.

While commercialization as a significant phenomenon began in the 1970s, particularly in the United States, the extent of this trend and its globalization have been most significant in the last 10–15 years.[11] This trend has been most prevalent across North America and Europe, but it has also occurred to varying degrees in many states in other regions, such as Brazil, China, India, Japan and South Korea. The trend is also evident in the creation of space programmes with commercial aspects in an increasing number of African states.[12] However, commercialization as a phenomenon occurs across the space sector and is not limited to, or the only defining feature of, NewSpace.

The global space sector is comprised of different actors engaging in space-related activities, including states and a variety of non-state actors, such as companies, industry associations and research institutes. NewSpace does not refer to a clearly demarcated subset of these actors, but it can be understood as broadly referring to the changing dynamics and the actors embracing them as part of their business model. New entrepreneurial space companies and start-ups of all sizes are especially likely to identify with NewSpace. They are also much more reliant on different types of private investment and venture capital.[13] The term NewSpace therefore broadly refers to companies in the space sector that have adopted such new structures and approaches. One such approach has been to adopt the lean organizational structures and flat hierarchies typically associated with Internet start-up companies.[14] For this reason, NewSpace has also been described as 'a disruptive sectorial dynamic' that features efficiency-driven concepts to make the space sector more profit driven and service oriented.[15]

[9] Schiller, Markus, ST Analytics, Interview with authors, 26 July 2022.

[10] Stotler, C., 'What is NewSpace', eds T. Ahmad and J. Su, *NewSpace Commercialization and the Law*, Centre for Research in Air and Space Law Monograph Series no. IV (William S. Hein & Co.: Getzville, NY, 2017), p. 3.

[11] Peeters, W., 'Towards a definition of new space? The entrepreneurial perspective', *New Space*, vol. 6, no. 3 (2018), pp. 187–89.

[12] Munsami, V., 'Why Africa needs to be in space', *World Today*, Aug./Sep. 2022.

[13] BryceTech, *Start-Up Space: Update on Investment in Commercial Space Ventures 2022* (BryceTech: Alexandria, VA, 2022).

[14] Prasad, N., 'Traditional space and NewSpace industry in India: Current outlook and perspectives for the future', eds R. P. Rajagopalan and N. Prasad, *Space India 2.0: Commerce, Policy, Security and Governance Perspectives* (Observer Research Foundation: New Delhi, 2020), p. 14.

[15] European Space Policy Institute (ESPI), *Commercial Space Exploration: Potential Contributions of Private Actors to Space Exploration Programmes—Executive Summary* (ESPI: Vienna, July 2019), p. 4.

NewSpace signifies the diversification of actors and activities in the global space industry in three ways. First, there is a significant increase of private actors in the space sector, including both large corporations (e.g. the US-based SpaceX) and small start-ups (e.g. the Indian company Pixxel). Second, the number of states with space ambitions and indigenous capabilities has also risen. Third, with a wide variety of new space applications, the types of activity have also transformed. The activities range from launching and maintaining mega constellations of satellites and on-orbit servicing to exploitation of space resources and space tourism.

Many of these activities are enabled or driven by technological advances. For example, improvements in satellite manufacturing, design and technologies have enabled the production of much smaller, lighter and cheaper satellites. In turn, these have spurred the development of mega constellations and created incentives for the development of launchers that can deliver small satellites into relevant orbits. These include 'small launchers', roughly defined as those able to carry a payload of up to 2000 kilograms to at least low Earth orbit, and 'micro launchers', with payloads of up to 500 kg, such as micro and nano satellites.[16]

Today's commercial space sector departs from the traditional state-centric model, in which only the public sector or traditional aerospace and defence companies develop the technology and conduct the activity. Rather, the sector currently benefits from different mechanisms for funding and partnerships involving the private sector. In some states, the national space sector is marked by a growing dependence on commercial entities and a rise in public–private partnerships. For instance, the US National Aeronautics and Space Administration (NASA) is no longer the USA's sole developer of space technologies but is also a customer of SpaceX (which provides, among other things, space launch services). The reliance of states on private-sector contracts for the provision of space technologies and services is expected to continue to grow. This includes increasing military usage of commercial satellite communications services.[17]

The types of contract between the public and private sectors have also begun to change. A preference has emerged for fixed-price contracts between government space agencies and private entities, rather than cost-plus contracts (where the contractor is reimbursed for its costs and paid an additional fee). Some space industry representatives have been vocal about the need for fixed-price contracts to incentivize performance and fair pricing.[18]

There is also increasing competition within the commercial space sector for both government and commercial contracts as space activities are no longer solely state-funded. Indeed, some have noted that the space industry 'has seen the inflow of significant [private] capital and has made technological advancements which have often overshadowed those made by their state-run counterparts'.[19] Venture capital funding has soared in recent years, with private investment in the space sector reported to be at its highest level yet in 2021, growing by 50 per cent from the previous year.[20] Such growth suggests that investors are motivated by the potential for high returns on investment and that there is a growing preference among NewSpace companies for such investment rather than traditional sources of funding such as loans from banks.

[16] Wekerle, T. et al., 'Status and trends of smallsats and their launch vehicles—An up-to-date review', *Journal of Aerospace Technology and Management*, vol. 9, no. 3 (July–Sep. 2017), p. 270.

[17] E.g. Erwin, S., 'DoD Satcom: Big money for military satellites, slow shift to commercial services', *SpaceNews*, 22 June 2022.

[18] E.g. Foust, J., 'Nelson criticizes "plague" of cost-plus NASA contracts', *SpaceNews*, 4 May 2022.

[19] Rajagopalan, R. P., Mohan, P. and Krishna, R., *India in the Final Frontier: Strategy, Policy and Industry*, Observer Research Foundation (ORF) Special Report no. 100 (ORF: New Delhi, Jan. 2020), p. 13.

[20] Sheetz, M., 'Investment in space companies hit record $14.5 billion in 2021, report says', CNBC, 18 Jan. 2022.

These developments are evidence of the increasing accessibility of the space industry to non-traditional private-sector participants. Yet, they simultaneously raise questions about whether the influx of new companies into the ecosystem can continue to be supported by the available or predicted size of the space market, especially in terms of launch demand and risk of oversupply.[21] A possible future consolidation of the global space sector could leave NewSpace companies holding dual-use space technology (such as sensitive SLVs) and production facilities, as well as individual engineers with significant know-how and experience, in a vulnerable financial situation. This could possibly be exploited for illicit procurement activities and pose new missile proliferation risks.

## Relevant actors in the global space sector

The global space sector spans a variety of states with different ambitions for space activities and non-state actors, including NewSpace companies and industry associations. A range of actors at the state level are involved in the regulation of space activities while others provide direction and define missions of national space programmes. The sector also includes a range of industry actors that could wittingly or unwittingly become involved in different types of proliferation scenario (described below)—but can also play an important role in reducing that risk.

### *State level: National space agencies and government regulators*

Structures of and relationships between licensing and administrative authorities in each state can vary significantly, as can the relationship between the government and private companies. As a result, clarity on structure and composition of the NewSpace industry is key to conceiving potential risks and illicit procurement pathways and to properly targeting outreach, awareness raising, training, oversight and enforcement activities.

Many governments are actively promoting the establishment of national space industries and the establishment of start-ups in the space sector to enable competitiveness, to enlarge the sector and to spur innovation. Governments often provide strategic direction to certain space activities and provide funding to their national space industry both through national space agencies and through direct funding or contracting to commercial space companies. At the same time as guiding and funding the industry's development, government ministries also serve to regulate it.

Among the many authorities with certain space-related roles are different authorities responsible for export controls, regulatory control of space operations (both launch and in-orbit operations) and promotion of space industrial development. There is often a lack of engagement and coordination between these authorities on missile proliferation risks linked to commercial space industry activities. According to one government advisor, inter-agency coordination can help identify relevant actors that are developing sensitive missile technology and raise awareness about export licensing obligations and missile proliferation risks.[22] National export control regulations are usually implemented by one or more national export licencing authorities. The authority responsible for dual-use export controls plays a crucial role in engagement with companies and research centres in the space sector to raise awareness, provide advice and training, and produce national guidance materials.

[21] Denis, G. et al., 'From new space to big space: How commercial space dream is becoming a reality', *Acta Astronautica*, vol. 166 (Jan. 2020), p. 440.

[22] Senior government advisor on export control technical policy, Interview with authors, 5 Aug. 2022.

National space agencies oversee and administer the implementation of a state's space programme. Traditionally, space agencies—for example, NASA in the USA—were the main actor in a state's space sector. They developed technology internally, managed a limited number of contractors and suppliers and provided funding to companies in the national space industry. With the commercialization of the space industry, the roles have changed: space agencies are now often customers seeking the goods and services of commercial actors. The increase of commercial space launch activities that are independent of national space programmes also means that the influence of governments on the commercial space industry has decreased. In particular, NewSpace companies are often much more oriented towards commercial demand than towards the agendas pursued by space agencies. However, government funding is still a significant factor and space agencies provide an important hub for organization and engagement for a country's space actors. Space agencies are thus still important for market-oriented NewSpace companies.

*Industry level: Companies and industry associations*

Different types of non-state actor participate in space activities at the industry level. However, the structure of the space industry, including the prevalence of NewSpace companies, differs significantly between those states with long-standing space programmes and large aerospace industries and those states that are recent entrants to the space sector and may have much smaller aerospace industries. For states with a long-standing space programme, large aerospace and defence companies are traditionally the contractors most closely tied to that programme. If there is a parallel missile programme, they are often also involved in the production of missiles. In some states with an established national space programme, there are also established commercial space companies (e.g. large satellite companies) that have long had a focus on commercial activities. Both aerospace and defence companies and established commercial space companies generally have a high level of awareness and experience with export controls and large compliance departments with an internal compliance programme (ICP).

The NewSpace industry ranges from small start-up companies to large aerospace and defence companies setting up dedicated innovation programmes that seek to emulate slim organizational structures and entrepreneurial approaches. Heavy launch service providers, small and micro launcher manufacturers and launch service providers, satellite manufacturers and operators, and a wide range of companies exploring space manufacturing and technology for other possible future space missions and commercial opportunities—indeed, companies with business models built on any space-based service—may consider themselves to be part of the NewSpace industry.[23] The range of different sizes and characteristics of companies that consider themselves to be part of the NewSpace industry means that the levels of awareness and the applicability of existing good practice and guidance materials for industry can vary significantly. A wide range of companies, research centres and universities also contribute to technology development or are part of the value and supply chains of products offered by the space industry to its commercial and state customers. Some NewSpace start-up companies have also been created directly out of university research programmes.

In most states with a commercial space industry there are well-established industry associations for the aerospace and defence sector or an association that is specifically for companies in the space sector. There are few examples of industry associations only comprised of NewSpace companies, but less formal organizations or interest

[23] See e.g. the overview of the British space sector in Innovate UK, 'UK space sector landscape map', [n.d.].

groups have often been formed in recent years.[24] Space industry associations provide a valuable forum, particularly for young companies to exchange information and experiences on compliance obligations, opportunities for engagement with government, and good practices in export control compliance procedures. They also often act as key intermediaries in engagement with government authorities and can bundle and amplify the communication of issues experienced by industry. They can also help disseminate government advice and guidance materials or produce good practice materials based on the input of their members and relevant authorities.

## The dual-use dilemma of space launch technology

Since the beginning of the space age, the development of rockets as SLVs has posed a dual-use dilemma: the same technologies that could be used to enable scientific discovery through the exploration of space can also be used to build delivery systems for nuclear weapons. Both the Soviet Union and the United States used ballistic missiles as the initial platform from which they developed the launch vehicles of their first satellites sent into orbit.[25] Other states' SLV programmes followed similar trajectories, and the national space industries that were built in support of these programmes have traditionally been strongly intertwined with the aerospace defence industry.

The technologies used in ballistic missiles—particularly in multistage intercontinental ballistic missiles (ICBMs)—are virtually the same as those used in SLVs built to deliver satellites into orbit.[26] However, that does not mean that an SLV can simply be used as an ICBM. From a technical perspective, staging mechanisms, propellants, airframes, flight systems and rocket motors and engines, among other things, can be the same in SLVs and missiles. Most other components required for SLVs and missiles—apart from the payload or warhead—also use similar technologies but require additional specifications according to the nature of the system.[27] Conversely, some states—most prominently Argentina and India—have reversed the traditional path and developed ballistic missile components from technology they had acquired for their civilian national space programmes.[28] Other states, such as Iran and North Korea, that claim to develop and test SLVs for a national satellite-launch capability have been accused of using these programmes as a test bed for ballistic missile components and to divert certain technologies to their parallel ICBM programmes.[29]

For all of their similarities, there are also differences between SLVs and ballistic missiles. Because of the differences in mission, their necessary trajectories and their payloads, the performance characteristics of an SLV and a ballistic missile differ, particularly in terms of the required velocity and ratio between the rocket stages.[30] Their technical and operational requirements can also differ because of their fundamentally different missions.[31] For example, an SLV launch can generally be prepared uncontested: the SLV can be assembled, erected and fuelled slowly and carefully to maximize safety and ensure optimal environmental conditions. In

[24] See e.g. the NewSpace initiative of the Federation of German Industries. Bundesverband der Deutschen Industrie (BDI), 'NewSpace', [n.d.].

[25] Karp, A., 'Space technology in the Third World: Commercialization and the spread of ballistic missiles', *Space Policy*, vol. 2, no. 2 (May 1986), p. 158; and Azcárate Ortega, A. and Stefanovich, D., 'Space launch vehicles and ballistic missiles', ed. P. Podvig, *Exploring Options for Missile Verification* (UNIDIR: Geneva, 2022), p. 43.

[26] MTCR, 'MTCR guidelines and the equipment, software and technology annex', [n.d.].

[27] Maitre and Moreau-Brillatz (note 2), pp. 15–16.

[28] Schmucker and Schiller (note 2), p. 330; and Maitre and Moreau-Brillatz (note 2), pp. 19–22.

[29] Lamson, J. and Krzyzaniak, J., 'To geostationary orbit and beyond? Assessing Iran's space launch goals and efforts', Arms Control Wonk, 4 Apr. 2022; and van Diepen, V. H., 'Burying the lede: North Korea conceals that "spy satellite" tests are first launches of new large ICBM', 38North, 16 Mar. 2022.

[30] Schmucker and Schiller (note 2), p. 331.

[31] Schmucker and Schiller (note 2), p. 330.

contrast, a road-mobile ballistic missile must be made ready for launch quickly and must be robust enough to be launched in various conditions. Yet, these differences are not equally significant when comparing different types of SLV and different types of ballistic missile. For example, strategic ICBMs often have their targets pre-identified and the target and their navigational and guidance data already loaded into the system, and they stand assembled in silos. Small SLVs are currently being developed for lighter and smaller satellite payloads, use solid-fuelled rocket boosters and may be road-mobile to enable a rapid response, for example to re-establish a space-based service that has been disrupted and requires a replacement satellite.[32] This adaptability and diversification of SLV technologies demonstrates the blurring of traditional distinctions between SLV and ballistic missile technologies. International transfers of SLVs and their major components are therefore treated as being as sensitive as those of missiles.

Concerns about rising commercialization in the global space sector and potential missile proliferation risks are not new: they have been raised on various occasions as commercialization of space activities occurred and expanded.[33] For example, the exchange of technical data as part of space cooperation projects has long raised concerns.[34] In the past, this dual-use problem mainly concerned the possible use of national space programmes developing SLVs to disguise the development of a national ballistic missile programme, particularly for ICBMs. Today, the range of space and space launch technologies that could be diverted to use in a missile programme has expanded. For example, the boom in the development and production of micro launchers by companies in the commercial space industry poses risks for the proliferation of medium-range ballistic missiles that could be developed using micro launcher technology or components.[35] In addition, many of the emerging technologies pioneered or adopted early by the NewSpace industry (e.g. additive manufacturing) could be used to enable qualitative improvements to existing production techniques and designs.[36] Some new concepts—for example, orbital cargo-retrieval systems currently being developed for future in-orbit manufacturing or space mining—essentially develop new types of targetable re-entry vehicle.

## Missile proliferation scenarios and risks

The growth of the commercial space sector in various states has broadened the range of possible missile proliferation scenarios involving transfers of SLV technology or where commercial space activities may be used to hide a ballistic missile programme. The dual-use nature of space technologies means that transfers of goods and technology and the provision of technical assistance (including transfers of know-how) can knowingly or unknowingly contribute to missile programmes. Almost all missile programmes have relied on foreign assistance or at least the procurement of components, subsystems or technology from foreign suppliers or the acquisition of know-how from foreign experts.[37] For example, both US and Soviet missile programmes relied on expertise from German missile engineers, and the proliferation of Soviet-designed Scud missiles

[32] E.g. Rocket Lab USA, 'Responsive space', [n.d.].

[33] E.g. Miller, J., 'U.S. uneasy over military potential of commercially produced rockets', *New York Times*, 12 Sep. 1981.

[34] Farand, A. and Bohlmann, U., 'ESA's cooperation with international partners—Export-control issues', *ESA Bulletin*, no. 118 (May 2004), p. 52.

[35] Schiller (note 9).

[36] Brockmann, K., *Additive Manufacturing for Missiles and Other Uncrewed Delivery Systems: Challenges for the Missile Technology Control Regime* (SIPRI: Stockholm, Oct. 2021).

[37] Schmucker and Schiller (note 2), p. xvii.

**Table 2.1.** Possible missile proliferation scenarios involving commercial space industry

| Scenario | Missile programme | National space programme | Commercial space industry | Proliferation risk |
|---|---|---|---|---|
| A. Space programme and industry to camouflage procurement | Yes (overt) | Yes | Yes | Diversion of space products, technology and know-how from the space programme and the commercial space industry; enables plausible deniability |
| B. Space programme and industry for covert procurement | Yes (covert) | Yes | Yes | Diversion of space products, technology and know-how from the space programme and the commercial space industry; enables official deniability |
| C. Space industry to camouflage procurement | Yes (overt) | No | Yes | Diversion of space products, technology and know-how from the commercial space industry; enables plausible deniability |
| D. Space industry for covert procurement | Yes (covert) | No | Yes | Diversion of space products, technology and know-how from the commercial space industry; enables official deniability |
| E. Space programme and industry as a hedge | No | Yes | Yes | Build-up of national expertise, capacities and industrial base, organizational structure and programme experience for a possible later initiation of a missile programme |
| F. Space industry as a hedge | No | No | Yes | Build-up of national expertise, capacities and industrial base for a possible later initiation of a missile programme |

and components has been the basis of numerous ballistic missile programmes in the Global South.[38]

States engaged in illicit procurement activities usually try to conceal that items or technical assistance are destined for a missile programme in order to circumvent export controls, sanctions or other applicable missile non-proliferation mechanisms.[39] States and non-state actors seeking to illicitly acquire missile technology may choose different ways of deceiving suppliers. They may mask the real end use or end user of a transfer or technical assistance, hide a covert missile programme, or establish a certain level of public deniability of their missile activities. They may also acquire relevant technology, know-how and industrial capacities that could readily be accessed or repurposed to help kick-start a missile programme—known as latent capabilities or hedging.

The range of scenarios considered below should not be understood as casting general suspicion on commercial and non-commercial space industries or as questioning states' right to the peaceful uses of outer space. However, they demonstrate a range of possible scenarios for state licencing and enforcement authorities to consider when assessing suspected proliferation activities of countries of concern or during risk-assessment procedures as part of export licencing.

[38] Schmucker and Schiller (note 2), pp. 185–86; and Potter, W. C. and Stulberg, A., 'The Soviet Union and the spread of ballistic missiles', *Survival*, vol. 32, no. 6 (1990).

[39] Zaborsky, V., 'Missile proliferation risks of international space cooperation', *World Affairs*, vol. 165, no. 4 (spring 2003), p. 186.

*Using a national space programme to camouflage procurement for a missile programme*

In this scenario, a state uses seemingly legitimate procurement for its national space programme as a cover to illicitly acquire goods and technology for a (covert or overt) missile programme (see table 2.1, items A–B). Because of the similarities between SLVs and long-range ballistic missiles, a national space programme seeking to build an indigenous SLV could ostensibly be presented to a supplier as the end user of sensitive missile technology. Particularly where a national space programme is paired with a space industry that also engages in commercial space activities, the true destination of items could be camouflaged during procurement.[40]

If the state's missile programme is known to the public, then the national SLV programme may be pursuing similar rocket or component designs to obfuscate the end use despite the additional scrutiny that would probably be applied by suppliers to transfers to this destination.[41] A supplier state that is willing to illicitly provide controlled missile technology may point to a space programme or commercial space industry in the importing state as a means of denying that it is supplying or assisting a known missile programme (see table 2.1, item A). The end use may also be quite indirect, such as where procured technology is used for developing and testing rockets with intercontinental range in a space launch configuration and the technology, test data and know-how is subsequently used to develop an ICBM. For example, Iran's Islamic Revolutionary Guard Corps is suspected of trying 'to develop large-diameter, solid-fuel rockets' as a space launcher in order to move closer to an ICBM capability.[42]

If the state's missile programme is still covert, there would probably be fewer suspicions about and questioning of the intentions behind the technologies pursued by the state's national space programme. However, because of the dual-use nature of SLV programmes, any SLV-development programme is usually closely scrutinized. Establishing a mature space programme for the sole purpose of diverting technology to a covert missile programme is unlikely to be cost-effective. Pursuing the legitimate objectives of a national or commercial space programme and diversion to a covert ballistic missile programme simultaneously could make detection more difficult. The income from commercial space activities could potentially also be used to offset some of the significant costs of such programmes over time. The existence of a space programme with SLV development alongside a covert missile programme may also be exploited for public deniability of missile activities (see table 2.1, item B).

*Using a commercial space industry to camouflage procurement for a missile programme*

In this scenario, a state without a national space programme uses procurement by its commercial space industry as a cover to illicitly acquire goods and technology for a (covert or overt) missile programme (see table 2.1, items C–D). Non-state actors in the space sector, including NewSpace companies, have increasingly engaged in the manufacturing of space technologies that pose proliferation risks. For example, SpaceX developed the Falcon Heavy heavy SLV, and a wide range of companies in various states are now developing, producing and testing a wide range of small and micro launchers, such as Rocket Lab's Electron and Orbex's Prime rockets.[43]

Because of the similarities of many small and micro launchers with the technology used in intermediate- and medium-range missiles, a state could establish or use a commercial space industry engaged in producing such launchers to camouflage

[40] Schmucker and Schiller (note 2), p. xvii.

[41] Zaborsky (note 39), p. 192.

[42] Krzyzaniak, J., 'Iran's military space program picks up speed', Terrain Analysis, Newlines Institute for Strategy and Policy, 27 Oct. 2021.

[43] SpaceX, 'Falcon Heavy', [n.d.]; Rocket Lab USA, 'Electron', [n.d.]; and Orbex, 'Orbex reveals first full-scale microlauncher rocket developed in Europe', Press release, 27 May 2022.

procurement and other activities linked to a known missile programme (see table 2.1, item C). Similar concealment activities have taken place in the past, such as when Argentina developed sounding rockets for 'weather research' which were subsequently converted to a short-range missile.[44] Commercial space companies could also conceivably be co-opted by their government to work as technology provider and procurement pipeline for a covert missile programme (see table 2.1, item D).

The extent to which a government exerts direct influence over companies in their domestic industries may affect its ability to implement such strategies. Shielding the true intent of the procurement effort would probably be more difficult when using private companies than it would with a state-controlled space programme. Nevertheless, it could also create an environment in which it would be more difficult to detect front companies established solely for illicit procurement. A state could conceivably encourage and support the development and growth of a domestic NewSpace industry with state funding to help create such an environment and attract a qualified workforce (including from abroad), technology and a supply chain that could be used to benefit an ongoing missile programme. Distinguishing such activities is inherently difficult, particularly where states seek to conceal the true ownership structures and links to military programmes. For example, Chinese efforts to procure dual-use technologies from Western companies have in the past made use of a range of acquisition strategies, including to benefit its missile and SLV programmes.[45]

*National space industry as a hedge for a possible future missile programme*

In this final scenario, a state chooses to pursue the establishment of a national space industry to create latent industrial and technological capabilities that could later be relied upon to kick-start and support a future ballistic missile programme (see table 2.1, items E–F). This type of strategy—where a state engages in legitimate research and industrial activities in order to be able to transform them into weapon applications if and when desired—is commonly referred to as 'hedging'.[46] States may pursue such a strategy to forego the possible negative reactions and limits on technology transfers that would be caused by a missile programme that is deemed illegitimate or destabilizing by potential supplier states.

Gaining experience in relevant technology areas can help improve performance of reverse-engineered systems and ultimately enable indigenous development efforts that are less reliant on foreign assistance and procurement.[47] Therefore, building the industrial base and as much indigenous expertise, production capabilities, and access to required materials and technology are key objectives for any state seeking to establish a missile programme, whether by way of reverse engineering certain components or systems or as the basis of an indigenous design. Proving intent behind such activities prior to obtaining convincing evidence of diversion or conversion to a missile programme is inherently difficult.

[44] Mistry, D. and Gopalaswamy, B., 'Ballistic missiles and space launch vehicles in regional powers', *Astropolitics*, vol. 10, no. 2 (2012), pp. 129–31.

[45] Boyd, D., Lewis, J. G. and Pollack, J. H., *Advanced Technology Acquisition Strategies of the People's Republic of China*, Defense Threat Reduction Agency (DTRA) Advanced Systems and Concepts Office Report no. ASCO 2010-021 (DTRA: Ft. Belvoir, VA, Sep. 2020), pp. 61–65.

[46] Davis, Z. S., 'Ghosts in the machine: Defense against strategic latency', eds Z. Davis, R. Lehman and M. Nacht, *Strategic Latency and World Power: How Technology is Changing Our Concepts of Security* (Lawrence Livermore National Laboratory: Livermore, CA, 2014), p. 25.

[47] Schmucker and Schiller (note 2), p. 323.

# 3. Applying MTCR export controls to the commercial space industry

This chapter focuses on the application to the commercial space industry of the MTCR guidelines and the equipment, software and technology annex and supplements. The approach of the Wassenaar Arrangement and its control lists are discussed where appropriate.

The MTCR provides guidelines and a control list for export controls on key rocket technologies required for both SLV and missile applications. These controls, when implemented through states' national regulations, apply equally to NewSpace companies, other companies in the wider commercial space industry and arms manufacturers. While there are limited exceptions for items destined for space launch activities for peaceful purposes, the MTCR annex provides comprehensive coverage of dual-use rocket technology. There have been specific presentations by MTCR partners and discussion within the MTCR on missile proliferation risks associated with the commercialization of the space industry, including the role of commercial small SLVs, since at least 2017.[48] In addition, the Wassenaar Arrangement also provides control lists that cover missile- and non-missile-related items developed and produced by the commercial space industry.

It is important for states and stakeholders in the NewSpace industry to understand the (*a*) applicability of licensing requirements and exceptions, (*b*) what distinguishes items that are subject to the 'unconditional strong presumption of denial' under MTCR category I, and (*c*) the application of specific types of export control. Compliance with some types of control may be particularly difficult for NewSpace companies. Several other instruments that complement export controls are of increasing importance in the context of the NewSpace industry, including foreign direct investment screening mechanisms and bilateral technology safeguards agreements.

## Application of MTCR and Wassenaar Arrangement guidelines to transfers of space technology

The MTCR guidelines for sensitive missile-related transfers provide the basic principles that underly the application of export controls to transfers of sensitive missile-related items. The guidelines explicitly say that MTCR export controls are 'not designed to impede national space programs or international cooperation in such programs as long as such programs could not contribute to delivery systems for weapons of mass destruction'.[49] This reflects the aspiration of the partners to limit the impact on peaceful space programmes while simultaneously qualifying this commitment by highlighting the possibility that a transfer to a space programme could contribute to a programme for CBN weapon-delivery systems. The MTCR guidelines further lists the 'capabilities and objectives of the missile and space programs of the recipient state' as one of the factors to be considered when evaluating export licence applications for transfers of listed items on a case-by-case basis.[50]

Neither the MTCR guidelines nor the annex provide for any general exceptions for transfers of items destined for national space programmes. More limited exceptions of a technical nature exist for specific items in the MTCR annex allowing them to be considered as category II items if certain conditions are met. For example, re-entry

[48] Senior government advisor on export control technical policy (note 22).
[49] MTCR, 'Guidelines for sensitive missile-relevant transfers', [n.d.], para. 1.
[50] MTCR, 'Guidelines' (note 49), para. 3.

vehicles designed for non-weapon payloads that are 'exported subject to end-use statements and quantity limits appropriate for the excepted [non-weapon payload] end-use'.[51]

The Wassenaar Arrangement does not specifically acknowledge any commitment to limiting the possible impact of export controls on national space launch activities and space programmes.

## Coverage of space launch technology by the MTCR annex and the Wassenaar Arrangement control lists

### *Coverage by the MTCR annex*

The MTCR annex controls 'space launch vehicles' as category I items if they are capable of carrying a 500-kilogram payload to a range of at least 300 kilometres, or if they include a category I subsystem.[52] The annex does not further define what constitutes an SLV. An 'unconditional strong presumption of denial' therefore applies to transfers of any launch vehicle with capabilities that surpass that payload–range threshold, regardless of whether it is a multistage heavy launch vehicle, a light launch vehicle or a micro launcher. Complete subsystems for category I SLVs—including individual rocket stages, re-entry vehicles, propulsion subsystems, guidance systems and thrust vector control systems with certain technical parameters—are also controlled as category I items.[53]

Complete SLVs with a range of 300 km capable of carrying a payload lighter than 500 kg are also controlled, but only as category II items.[54] This means that they are not subject to a presumption of denial, but licensing requirements still apply. Category II also includes controls on dual-use items, software, materials and technology in all areas of rocket technology. This includes propulsion, propellants, instrumentation and navigation, flight control, avionics, launch support, computers, test facilities and equipment, and modelling and simulation equipment. The vast majority of space industry activities that involve any transfer of items or technical data to another state or provide technical assistance to an end user in another state are therefore likely to be subject to at least some export licensing requirements.

### *Coverage by the Wassenaar Arrangement control lists*

The Wassenaar Arrangement dual-use list covers a range of space technologies, including SLVs, suborbital craft, SLV carrier or launch aircraft, spacecraft, and spacecraft buses, as well as certain spacecraft payloads, spacecraft on-board systems or equipment, and terrestrial equipment.[55] SLVs are also not further defined by any technical parameters in the Wassenaar Arrangement dual-use list. The dual-use list also covers 'liquid rocket propulsion systems' and 'solid rocket propulsion systems', as well as a range of specially designed components for either type of propulsion system.[56] The controls on spacecraft include 'active and passive satellites and space probes' and further extend to 'on-board systems or equipment' and terrestrial equipment 'specially designed for "spacecraft"'—thus controlling a wide range of satellites, their components and support facilities.[57]

[51] See the note attached to category I, item 2.A.1 of MTCR, 'Annex' (note 4), p. 19.

[52] See category I, item 1.A.1 of MTCR, 'Annex' (note 4), p. 16.

[53] See category I, item 2.A.1 of MTCR, 'Annex' (note 4), pp. 18–19.

[54] See category II, item 19.A.1 of MTCR, 'Annex' (note 4), p. 74.

[55] Wassenaar Arrangement, *Public Documents*, vol. II, *List of Dual-Use Goods and Technologies and Munitions List* (Wassenaar Arrangement: Vienna, 22 Dec. 2021), p. 158.

[56] See category 9, items 9.A.5–9.A.8 of Wassenaar Arrangement (note 55), pp. 159–60.

[57] See category 9, items 9.A.4.e and 9.A.4.f of Wassenaar Arrangement (note 55), p. 158.

The Wassenaar Arrangement also applies controls to a wide range of dual-use goods, equipment and technology that is 'space qualified', for example optical sensors. The dual-use list defines 'space qualified' as 'Designed, manufactured, or qualified through successful testing, for operation at altitudes greater than 100 km above the surface of the Earth'.[58] The Wassenaar Arrangement munitions lists covers rockets, missiles and spacecraft that are specially designed or modified for military use.[59]

### Transfers of technology and technical assistance

The export controls prescribed by the MTCR also apply to transfers of technology and technical assistance related to the specific goods listed in the annex. In this context, 'technology' is defined in the annex as 'specific information which is required for the "development", "production" or "use" of a product'.

The annex distinguishes between 'technical data' (i.e. blueprints, plans, diagrams, models, formulae, algorithms, tables, engineering designs and specifications, and manuals and written instructions) and 'technical assistance' (i.e. instruction, skills, training, working knowledge and consulting services).[60] Technical data can be tangible and in a physical form, but it can also be transferred in an intangible way; for example, if it is in the form of electronic data, through electronic file sharing or transfers.[61] Technology transfers, particularly technical assistance, can also take the form of know-how transfers through training, instruction and apprenticeship, and also through consulting services. Intangible transfers of technology are a particular problem for export controls as these transfers take place independent of national borders and physical customs controls.

Controls on transfers of technology and the provision of technical assistance are particularly important in the case of proliferation risks linked to the commercial space industry. For a missile programme, the importance of know-how, organizational experience, services and technical data can match—or even exceed—the importance of many of the components that could be procured from the commercial space industry. Notably, the components, launch vehicles and test data for small launchers and micro launchers may be closer to the desired missile design, and so both tangible items and related technical data and know-how can be highly relevant to a missile programme. According to a representative of a small launcher company, for NewSpace start-ups with little prior experience in export control compliance, understanding the cases in which controls on transfers of technology and technical assistance apply and what technical data is subject to controls is among the most difficult aspects of export controls.[62]

Controls on technical assistance can also be applied to the provision of services less obviously connected to missile technology. For example, providers of commercial satellite imagery increasingly allow customers to task a satellite to collect imagery of an area on the Earth. This could potentially be for the purpose of providing imagery data for missiles that use scene-matching terminal-guidance systems. According to a senior government advisor, this type of imagery could be used as targeting data for missiles capable of carrying CBN weapons and the provision of such a service may

[58] Wassenaar Arrangement (note 55), p. 232.

[59] See ML4.a of Wassenaar Arrangement (note 55), p. 185. See also Horton, A., British Department of International Trade, 'Space, the international export control regimes and the UK's strategic export controls', Presentation, 8 Feb. 2018.

[60] MTCR, 'Annex' (note 4), pp. 13–14.

[61] Bromley, M. and Maletta, G., *The Challenge of Software and Technology Transfers to Non-proliferation Efforts: Implementing and Complying with Export Controls* (SIPRI: Stockholm, Apr. 2018).

[62] Thompson, Alan, Head of Government Affairs, Skyrora Ltd, Interview with authors, 3 Aug. 2022.

constitute controlled technical assistance.[63] However, the implementation of controls on technical assistance—including the types of mechanism that are used to license, monitor and enforce controls on technical assistance—varies considerably between states.[64]

### Catch-all controls

Catch-all controls are an export control mechanism that, under certain circumstances, allow a state to impose licensing requirements on transfers of items that do not appear on its control lists. Since 2003 the MTCR guidelines have required the partners to have catch-all controls as part of their national export control systems.[65] The MTCR guidelines stipulate that, under such a catch-all provision, a state can impose licensing requirements if its competent authorities inform the exporter 'that the items may be intended, in their entirety or part, for use in connection with delivery systems for weapons of mass destruction other than manned aircraft'.[66] Catch-all mechanisms rely on awareness and due diligence by industry and researchers because they create an obligation for an exporter to notify the national licensing authority if it is 'aware that non-listed items are intended to contribute to such activities, in their entirety or part'.[67] Based on such a notification, the competent authority can determine whether to apply a licensing requirement. Effective use of catch-all controls is thus highly dependent on (*a*) the export control authorities having access to relevant information and intelligence, (*b*) the strength of the due-diligence and compliance procedures of the exporting parties (individuals, companies and research institutions), and (*c*) good cooperation and communication between the exporting parties and the export control authorities.

With the rise in commercialization, NewSpace companies are making extensive use of emerging technologies and are developing innovative products. Since many of these are only covered by list-based controls to a limited extent, the use of catch-all controls is particularly important. Such controls are a versatile tool to address emerging technologies; for example, they are being applied to transfers of additive manufacturing machines and the build files used by those machines.[68]

Catch-all controls enable states to intervene and impose a licensing requirement on transfers of otherwise uncontrolled items in situations where states have relevant intelligence about a possible end use in a delivery system and want to deny the licence or want to receive additional information and assurances through a licensing application. Catch-all controls can also be applied to transfers of technical data and technical assistance related to unlisted items transferred as part of international collaboration between space companies and research centres, where the supplier state's authorities are aware that the end use could be in a CBN weapon or delivery system programme.

### Good practice and guidance materials

The MTCR partners have developed several good practice or guidance documents, but they are currently only shared among the partners and are not publicly accessible. In contrast, all other major multilateral export control regimes publish at least some

[63] Senior government advisor on export control technical policy (note 22).
[64] For a more comprehensive analysis of controls on technical assistance see Bromley and Maletta (note 61).
[65] MTCR, 'Frequently asked questions (FAQs)', [n.d.].
[66] MTCR, 'Guidelines' (note 49), para. 7.A.
[67] MTCR, 'Guidelines' (note 49), para. 7.B.
[68] Brockmann (note 36).

guidance materials. These are largely targeted at states rather than aimed at exporters, but there are exceptions. These include, for example, the Wassenaar Arrangement's guidance for companies' ICPs.[69] The United States at irregular intervals publishes updated versions of its MTCR handbook, which provides explanations and descriptions of the items included in the MTCR control list, including SLV and other space-related technologies.[70]

Several MTCR partners have established national guidance or good practice documents specifically for the space industry. For example, the US Department of Commerce's Office of Space Commerce and the Federal Aviation Administration's Office of Commercial Space Transportation publish a guide to US export controls specifically for the commercial space industry.[71] The European Union (EU) has also developed guidance materials for companies—for example on ICPs and for research and academia—that could be useful for EU-based exporters in the space sector.[72] However, the EU's guidance materials do not specifically target the space sector or the NewSpace industry.

### Complementary instruments: Foreign direct investment screening

The scope of the MTCR is limited to harmonizing export control policies and control lists, but the discussions within its different bodies—particularly in the licensing and enforcement experts meeting (LEEM)—at times also cover a wider range of strategic trade control measures that are linked to export controls. One such policy tool that is of relevance in the context of trends in the NewSpace industry is FDI screening.

Foreign direct investment is generally defined as 'cross-border investment in enterprises with the objective of establishing a lasting and significant influence over business activities'. Importantly, in FDI, transfers of capital and (partial) ownership may be accompanied by transfers of or granting access to other resources, including technology.[73] Thus, FDI is another means through which technology transfers can be enabled or access to technology obtained.

The regulatory frameworks establishing FDI screening mechanisms usually identify a set of critical infrastructures, industries and technologies where foreign investment beyond a certain threshold triggers a screening procedure. Such mechanisms enable national authorities to apply additional scrutiny and provide possible grounds and means for interventions, including blocking certain deals, on a case-by-case basis. Many states use their export control lists as a reference for which transfers of military and dual-use technologies through FDI can be made subject to screening procedures.[74] For example, to define 'critical technologies and dual use items' that should be considered when applying FDI screening, the EU's FDI screening regulation

[69] Wassenaar Arrangement, 'Best practice guidelines on internal compliance programmes for dual-use goods and technologies', 2011.

[70] US Government, *Missile Technology Control Regime (MTCR) Annex Handbook 2017* (MTCR: 2017).

[71] US Department of Commerce (DOC), Office of Space Commerce and Federal Aviation Administration (FAA), Office of Commercial Space Transportation, *Introduction to US Export Controls for the Commercial Space Industry*, 2nd edn (DOC/FAA: Washington, DC, Nov. 2017).

[72] European Commission, Commission Recommendation (EU) 2019/1318 of 30 July 2019 on internal compliance programmes for dual-use trade controls under Council Regulation (EC) no. 428/2009, *Official Journal of the European Union*, L 205, 5 Aug. 2019; and European Commission, Commission Recommendation (EU) 2021/1700 of 15 September 2021 on internal compliance programmes for controls of research involving dual-use items under Regulation (EU) 2021/821 of the European Parliament and of the Council setting up a Union regime for the control of exports, brokering, technical assistance, transit and transfer of dual-use items, *Official Journal of the European Union*, L 338, 23 Sep. 2021.

[73] Deutsche Bundesbank, 'Methodological notes on foreign direct investment', 4 June 2019.

[74] Bromley, M. and Brockmann, K., 'Controlling technology transfers and foreign direct investment: The limits of export controls', *SIPRI Yearbook 2018: Armaments, Disarmament and International Security* (Oxford University Press: Oxford, 2018).

refers to the EU Dual-use Regulation, which includes the EU's common control list—which in turn incorporates the MTCR's control list.[75]

While some of the objectives of FDI screening mechanisms—particularly strategic industrial considerations and national security—are more controversial, there is broad agreement among states about the common aim of curbing the proliferation of CBN weapons and their delivery systems.[76] As many of the investment models used by NewSpace companies to raise capital constitute FDI, FDI screening mechanisms can help identify investments that could result in sharing of sensitive technologies related to missiles and other CBN-delivery systems. By maintaining its control list, the MTCR is already indirectly contributing to the effective application of screening mechanisms to help prevent transfers of MTCR-controlled technologies by means other than export. Scrutinizing investors and significant shareholders of recipient space companies may also be part of the know-your-customer principle applied by exporters and the assessment of licence applications by export licensing authorities.[77]

### Complementary instruments: Technology safeguards agreements

Technology safeguards agreements are another type of instrument that could complement export controls in seeking to prevent space programmes and commercial space industries contributing to CBN-capable missiles. While safeguards agreements have long remained exclusive to the nuclear field, experts have been discussing their possible use for space programmes and commercial space launch activities for decades.[78]

The topic has gained more attention in the context of the growing number of spaceports being established in more and more states. As many states with an emerging NewSpace industry may not have access to or sufficient capacity at an appropriate domestic spaceport for space launches and tests, the demand for using spaceports abroad is increasing.[79] Using a spaceport or other launch facility in another state involves the export of the launch vehicle and its payload to that state. As this would often mean the transfer of category I items, doing so without the risk of providing access to the items and related information requires additional precautions and assurances.[80] Establishing a technology safeguards agreement between the state where the launch service provider is located and the state where the spaceport is located could be one such assurance. Such an agreement may establish rules on limiting access to launch vehicles, payloads, the launch or flight test data, and the technical assistance for analysing the data (including in case of launch failures). The USA has signed bilateral technology safeguards agreements with several states in recent years, including Brazil and New Zealand.[81] The United Kingdom is reportedly discussing such an agreement with Australia.[82]

[75] Regulation (EU) 2019/452 of the European Parliament and of the Council of 19 March 2019 establishing a framework for the screening of foreign direct investments into the Union, *Official Journal of the European Union*, L 79 I, 21 Mar. 2019, Article 4.1(b). The EU Dual-use Regulation is Regulation (EU) 2021/821 of the European Parliament and of the Council of 20 May 2021 setting up a Union regime for the control of exports, brokering, technical assistance, transit and transfer of dual-use items (recast), *Official Journal of the European Union*, L 206, 11 June 2021.

[76] Ghiretti, F., 'Screening foreign investment in the EU—The first year', Mercator Institute for China Studies (MERICS), 14 Oct. 2021.

[77] US Department of Commerce, Bureau of Industry and Security, 'Know your customer guidance', 2020.

[78] Zaborsky (note 39), p. 191.

[79] SpaceTec Partners, 'Space launch market analysis: HIE due diligence support', Feb. 2021, p. 15.

[80] MTCR, 'Guidelines' (note 49).

[81] New Zealand Government, 'NZ–US Technology Safeguards Agreement reached', 14 June 2016; and Reuters, 'Brazil Senate approves technology safeguard agreement with U.S.', 13 Nov. 2019.

[82] British Foreign, Commonwealth and Development Office, 'UK–US Technology Safeguards Agreement (TSA) for spaceflight activities: Understanding the TSA', 8 Feb. 2021; and Tehan, D., Australian Minister for Trade, Tourism and Investment, 'New measures to help grow Australia's civil space sector', 1 July 2021.

Technology safeguards agreements have direct relevance to transfers of items controlled according to the MTCR guidelines and control lists. Discussing the utility and design of such agreements and their possible viability as government-to-government assurances satisfying the requirement raised by the MTCR guidelines would thus be a valuable exercise.

# 4. Regulation and awareness in the NewSpace industry

NewSpace companies are subject to a range of domestic regulations and international rules on different aspects of their space-related activities. As NewSpace companies range from large corporations to smaller start-ups, their awareness of regulations and even relationships with national regulators can vary considerably. While establishing domestic forms of governance is mandatory for states according to international space law, there is no uniformity in these domestic policies.[83] Indeed, several states with active commercial space industries are yet to introduce national space legislation. While multilateral discussions have attempted to address this lack of harmonization, there continues to be a patchwork of varying domestic space regulation, which in turn creates widely different environments for private entities. This can also be confusing for new entrants in the NewSpace industry and can make it difficult to prioritize building compliance systems for certain regulations and seeking advice where required.

While international space law does not create significant hurdles for private-sector participation, the onus is on states to clarify priorities and introduce domestic policies that incentivize and support private-sector participation. Export control legislation is one of the few areas where established regulatory frameworks often already exist. However, in many cases national authorities' discussions with the space industry on regulatory frameworks do not include discussions of export controls and resulting obligations for commercial space companies.

The NewSpace industry is frequently attributed with a lack of awareness of export controls. However, based on interviews conducted for this study, companies newly entering the sector are usually quickly aware of the existence of export controls and that they may apply to some parts of their activities. For example, small launcher, micro launcher and satellite companies are generally aware that transferring their rockets or satellites to a launch facility or spaceport in another state is subject to export controls and a series of other regulations, according to a representative of one such company.[84] In addition, the US International Traffic in Arms Regulations (ITAR) is infamous for its wide-ranging implications for the space industry within and outside the United States.[85] Interviews with NewSpace companies, industry associations and national export control authorities conducted as part of this study suggest that there is often no general lack of awareness. Rather, there is a lack of in-depth understanding of the applicability of national export controls and a lack of awareness of the underlying proliferation risks among new entrants to the NewSpace industry. For example, companies are often less aware of how international cooperation and exchanges that form part of their development, design and engineering work can involve transfers of technology that are subject to export controls. Similarly, according to interviewees, companies (and sometimes even government agencies) may have difficulties determining the applicability of export controls to transfers of technical data, such as, for example, technical data that must be provided to a launch facility abroad prior to a launch and the subsequent transfer of data collected during the launch.[86]

[83] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty), opened for signature 27 Jan. 1967, entered into force 10 Oct. 1967, British Foreign Office, Treaty Series no. 10 (1968), Article VI.

[84] Thompson (note 62).

[85] US Department of State, Directorate of Defense Trade Controls, 'The International Traffic in Arms Regulations (ITAR)', [n.d.]. See also Hoffner, J., 'The myth of "ITAR-free"', Aerospace Security, Center for Strategic and International Studies (CSIS), 15 May 2020.

[86] Senior government advisor on export control technical policy (note 22).

Anecdotal evidence from interviews with NewSpace companies suggests that direct engagement with the national licensing authority helps companies both to improve their internal compliance practices and to understand the underlying proliferation risks.[87] Initial contacts with licensing and enforcement agencies have also caused some companies to decide to become more involved in aerospace or space industry associations and to bring their perspectives and interests to discussions within industry and to periodical engagement with national regulators and governmental experts.[88] However, not all states currently have the capacity to provide extensive individual advice to companies. The provision of guidance materials and regular engagement with groups of other industry stakeholders could make such activities more efficient and allow a tie-in with related activities and training provided by industry associations or similar frameworks.[89]

National outreach to industry and awareness-raising programmes need to be tailored to the differences in NewSpace companies, as they vary in size, structure and awareness and in their engagement with peers, industry associations and government. Clearly communicating the benefits that companies can derive from these activities can help increase participation. For example, according to one expert involved in outreach activities, companies may be more willing to participate in such an event if it combines a training component with an access component—thus both enabling companies to improve awareness and understanding of their export control compliance obligations and giving them an opportunity to discuss specific cases and questions with the regulator.[90]

Many NewSpace companies rely on a lean organizational structure and export control is just one among many responsibilities of a single person or a small team in charge of compliance or legal and government affairs more broadly. Providing incentives for participating in awareness-raising and training programmes can help generate interest and improve participation despite such constraints.

[87] Thompson (note 62).

[88] On e.g. the participation of NewSpace companies in the UK's Export Group for Aerospace, Defence & Dual-use (EGADD) see EGADD, 'About', [n.d.].

[89] Viski, A. and Jones, S., *Towards Outreach 2.0: Emerging Technologies and Effective Outreach Practices* (Strategic Trade Research Institute: Washington, DC, Feb. 2021).

[90] Nayan, Rajiv, Senior research associate, Manohar Parrikar Institute for Defence Studies and Analyses, Interview with authors, 28 July 2022.

# 5. Strengthening the MTCR's efforts to address proliferation risks posed by NewSpace

The commercialization of the space industry and the advent of NewSpace are changing the nature of the space sector. They are creating new possible proliferation pathways for missiles and other delivery systems capable of delivering chemical, biological and nuclear weapons and challenging the effective application of the export controls prescribed by the Missile Technology Control Regime. An unprecedented number of actors from an increasing number of states participate in the space sector and have access to dual-use space technology, including missile-related space launch technology. Space launch vehicle technologies have diversified. In particular, small and micro launchers are increasingly configured for rapid deployment and launch or are even road-mobile, thus more closely resembling ballistic missiles. These trends also influence the possible missile proliferation scenarios that states should consider and guard against.

The MTCR continues to be the key missile non-proliferation instrument and the application of the MTCR guidelines and annex are indispensable for addressing the challenges raised by NewSpace and the commercialization of the global space sector. The following measures could help the MTCR adapt and ensure the effective application of and compliance with export controls in the NewSpace industry.

### Coordinating export control policies on the commercial space sector

The main function of the MTCR is the coordination of export control policies to prevent the proliferation of missiles and other delivery systems capable of delivering CBN weapons. For this purpose, the MTCR partners should continue discussions on the impact of the changing nature of the space industry on the risk of space programmes and the NewSpace industry contributing to missile proliferation.

As well as coordinating the national regulations that implement the MTCR guidelines and control lists, the MTCR also has a key role in facilitating discussions on complementary instruments linked to export controls on missiles and other CBN weapon-delivery systems. This is ever more important as the global expansion of the NewSpace industry is increasing the access of states beyond the membership of the MTCR and of non-state actors to space launch and other missile-related technologies. Effective and more harmonized controls through the MTCR—and through the Wassenaar Arrangement—can help states to implement appropriate levels of control and to better target engagement with their national space industries and relevant scientific communities.

### Maintaining control lists

A key task of the MTCR partners continues to be the tracking of developments in missile technology, including technical developments in civilian space programmes and the commercial space industry. Technological innovation is being dispersed ever more widely and the space industry is now developing specific launch vehicles and spacecraft for commercial non-state customers. This means that the MTCR partners' monitoring and engagement activities need to include a wider range of actors and activities than was previously the case in the space sector. The MTCR partners could better adjust to the changing nature of the space industry by adopting or studying good practices and lessons learned from other sectors—such as the biotechnology

sector, where start-ups and small to medium-sized enterprises (SMEs) develop and produce sensitive dual-use goods and technology.

Nevertheless, some states may find it difficult to meet the requirement for having the appropriate expertise in or available to licencing authorities or to provide those agencies with sufficient resources and capacity. They should make efforts to build up or improve access to the required expertise. Specific areas that warrant scrutiny include small and micro launchers for small satellites, spaceplanes, and orbital cargo-retrieval systems (re-entry vehicles) developed for in-orbit manufacturing or space mining.

## Outreach and awareness raising

*Outreach to and engagement with the NewSpace industry*

Raising the level of awareness among actors in the NewSpace industry—particularly among those companies that are modelled on lean, goal-oriented start-up structures and may have limited compliance functions or small compliance departments—is important to ensure compliance with export controls. The MTCR partners and other states with a NewSpace industry should engage in, and where appropriate expand, activities to raise the level of awareness about the proliferation risks that are posed by transfers of many of the technologies pursued by the NewSpace industry, including small and micro launchers, orbital cargo-retrieval systems or space debris-removal systems.

*Dialogue among MTCR partners and outreach to adherents and non-partners*

Outreach on this issue should not be confined to national activities of the MTCR partners, but should also continue to be the subject of discussions within the MTCR and during outreach activities to the three MTCR adherents and to non-partners with relevant space industries. Outreach activities should also extend to other multilateral missile non-proliferation instruments and should take place during other non-proliferation and export control activities in which the chairs of the MTCR plenary or expert meetings participate. This could help inform MTCR partners, adherents and states outside the MTCR with emerging NewSpace sectors about the possible scenarios involving the space industry that pose proliferation risks, including how these may specifically apply to NewSpace. As the global NewSpace industry has expanded well beyond the MTCR partners, outreach to non-partners on this topic is particularly important.

## Good practice and guidance materials

The MTCR partners should engage in dedicated discussions to share their experiences, challenges and good practices in reaching out to, raising awareness among and monitoring developments in the space industry, particularly involving companies and start-ups in the NewSpace industry. A discussion on conducting effective risk assessments of recipient states' space programmes and commercial space industries could also benefit the partners in applying appropriate levels of restrictiveness in their licencing decisions. Partners with relevant experience should prepare presentations for the next licensing and enforcement experts meeting or a combined meeting of the LEEM, the technical experts meeting (TEM) and the information-exchange meeting (IEM).

Following the sharing of good practices, the partners should consider developing targeted guidance materials concerning the implementation of export controls by

the commercial space industry. To the best knowledge of the authors, the MTCR has not developed any guidance or good practice material specifically targeting the space industry. Even if such guidance or good practice material existed, the decision of the MTCR to restrict access to this type of MTCR document to the partners alone prevents it from benefitting a wider range of states. Broader, public dissemination would allow it to become a reference or standard for other guidance or good practice documents developed outside the MTCR.

The partners should also consider engaging in a broad dialogue on the implementation of other complementary strategic trade control instruments that are linked to export controls and could help address challenges and specific cleavages created by the changing nature of the NewSpace industry. For example, the partners could share experiences of applying FDI screening mechanisms to foreign investments in companies in the commercial space industry.

### Dialogue and coordination with multilateral instruments and international organizations

*Inter-regime dialogue with the Wassenaar Arrangement*

The MTCR partners should engage in inter-regime dialogue with the Wassenaar Arrangement on the application of export controls to emerging space technologies and the challenges posed by the NewSpace industry and the commercialization of the global space industry. Companies in the NewSpace industry are significantly affected both by MTCR controls on launch vehicles and related technologies and by Wassenaar Arrangement controls on spacecraft including satellites. The MTCR should engage with the Wassenaar Arrangement to discuss technical developments and coordinate on how the two regimes' controls apply, for example, to new small and micro launchers, spaceplanes and other reusable spacecraft and orbital cargo-retrieval systems, and whether such controls should be expanded in the future by either regime.

The development of guidance materials for the commercial space industry, including NewSpace companies, would ideally build on the sharing of experiences and good practices in the implementation of MTCR and Wassenaar Arrangement controls by participating states in either regime. The partners could prepare such a dialogue through the MTCR's informal mechanism for setting up technical inter-regime dialogues, drawing on lessons learned from previous inter-regime dialogues.[91]

*Engagement with the Hague Code of Conduct on complementary transparency, confidence-building and safeguards measures for national space activities*

The MTCR partners should continue regular engagement and dialogue with the Hague Code of Conduct, including through their chairs making presentations to the annual plenaries of the other. Dialogue could also be promoted through both instruments regularly sending representatives to international events on missile proliferation.

Transparency and confidence-building measures as they relate to commercial space industry activities should be one focus area of future events. For example, the HCOC chair could be invited to share experiences and perspectives from the HCOC on the challenges posed by NewSpace at the upcoming MTCR plenary in Switzerland. Transparency in NewSpace industry activities, including those involving commercial programmes to develop relevant types of SLV, can help states better understand the intentions of space launch activities and assess licensing applications from importers

[91] Brockmann, K., *Challenges to Multilateral Export Controls: The Case for Inter-regime Dialogue and Coordination* (SIPRI: Stockholm, Dec. 2019).

in states with such programmes.[92] Sharing of information on such activities in addition to information on SLV development programmes—either through the HCOC or publicly—helps apply appropriate levels of control without compromising competitiveness and maintaining a level playing field. If states and, to a lesser extent, companies were to improve the levels of transparency in commercial space activities, including of NewSpace companies, and in the development of all types of SLV and major subsystems and commercial space launches and tests, it would mutually benefit the MTCR partners and the states subscribing to the HCOC. It would also create incentives for more detailed annual declarations to the HCOC and could reduce any undue impact of export controls on international cooperation and trade as part of commercial space activities.

The MTCR partners should also extend their dialogue on good practices concerning technology safeguards arrangements for spaceports and other space launch facilities to the HCOC subscribing states and international organizations that are important stakeholders. The latter includes the United Nations Office for Outer Space Affairs (UNOOSA) and the International Civil Aviation Organization (ICAO).

[92] Maitre and Moreau-Brillatz (note 2), p. 25.

# About the authors

**Kolja Brockmann** (Germany) is a senior researcher with the SIPRI Dual-use and Arms Trade Control Programme. He also leads SIPRI's project 'Quo vadis MTCR? The Missile Technology Control Regime at a crossroads'. Brockmann conducts research in the fields of export control, non-proliferation, sanctions and technology governance. His recent work has focused on the multilateral export control regimes, post-shipment controls, and non-proliferation and export control challenges linked to additive manufacturing and hypersonic missile technology.

**Nivedita Raju** (India) is a specialist in space security. She is a researcher with the SIPRI Weapons of Mass Destruction Programme. She also coordinates activities for SIPRI's participation in the EU Non-proliferation and Disarmament Consortium (EUNPDC), including the EUNPDC Policy Paper series. Raju was previously a research fellow at the Open Lunar Foundation and a research assistant on various projects for McGill University, including the *Manual on International Law Applicable to Military Uses of Outer Space* (MILAMOS).

**STOCKHOLM INTERNATIONAL PEACE RESEARCH INSTITUTE**
Signalistgatan 9
SE-169 72 Solna, Sweden
Telephone: +46 8 655 97 00
Email: sipri@sipri.org
Internet: www.sipri.org