Arms Control and Delivery Vehicles: Challenges and Ways Forward

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ABSTRACT
Nuclear arms control remains a priority for the foreseeable future for many stakeholders, and proposals have emerged to focus on capping nuclear warheads of the main nuclear-weapon states. However, delivery vehicles are another source of instability and arms race dynamics. Whether they are coupled with weapons of mass destruction or considered exclusively in the context of their use with conventional weapons, missiles are increasingly transferred, produced, modernized, and used in military conflicts. The development of offensive capabilities can also lead to a negative regional or global spiral with the increased deployment of defensive systems, and in response, new efforts to procure offensive weapons. It is therefore useful to keep thinking about ways to limit the destabilizing effect of these weapon systems. Some legal instruments currently exist in unilateral, bilateral or multilateral forums. Their focus may be limited to nonproliferation or they may cover a broader range of issues and address the behavior of states acquiring these delivery vehicles. This article will discuss ways in which these instruments can evolve to better respond to current trends and dynamics regarding missiles, but also will suggest new initiatives, particularly confidence-building measures, that could be useful to reduce the destabilizing effect of these systems.

Introduction
Nuclear proliferation remains a key concern of the international community, with North Korea emerging as a full-fledged nuclear power and Iran testing the limits of the nuclear nonproliferation regime. Curbing the use of chemical weapons by states in domestic conflict, and especially in the framework of the conflict in Syria, has also been seen as an unsolved challenge in the last decade. The efforts to destroy biological weapons effectively and prevent their proliferation have also experienced some challenges, especially with regard to verification. However, for these three types of weapons, the international community is able to resort to quasi-universal norms such as the Treaty on the Non-Proliferation of Nuclear Weapons (NPT), the Chemical Weapons Convention (CWC) and the Biological Weapons Convention.
(BWC), which are supported by an institutionalized framework for the first two with respectively the International Atomic Energy Agency (IAEA) and the Organization for the Prohibition of Chemical Weapons (OPCW).

The absence of such a strong norm dealing with the proliferation of missiles may have reduced the legitimacy of and the international support for the efforts to curb the proliferation of these systems. However, this phenomenon has remained an important matter of concern in recent years and should continue to weigh on international security in the future. First, proliferating countries such as North Korea (nuclear) and Syria (chemical), as well as Iran, a country suspected of nuclear ambitions, are investing in missile capabilities. Missiles are considered a privileged means of delivery for weapons of mass destruction (WMD), due to their speed, ability to avoid interception, and ease of concealment prior to launch (Trezza 2013). North Korea and Iran in particular are mastering advanced missile technologies that enable them to deploy increasingly long-range and accurate systems. These countries are also involved in delivery vehicle proliferation dynamics with the dissemination of missiles in the Middle East in particular, a region with a number of missile possessors, such as Saudi Arabia, Turkey, Bahrain, Qatar, the United Arab Emirates, and Israel.

The building tensions on the Korean Peninsula in 2017, in parallel with the ambitious missile-testing agenda of the regime, have shown the destabilizing impact of these activities. Concerning Iran, the development of the country’s missile programs has been one of the reasons that led to the collapse of the Joint Comprehensive Plan of Action and the difficulty of reviving it from 2021 onward (Cordesman 2021).

At the other end of the spectrum, the spread of short-range missiles is leading to unprecedented use of these missiles in combat, in intrastate and interstate conflicts, such as the war in Yemen or the conflict between Armenia and Azerbaijan. The use of missiles in these conflicts reflects a tendency to exploit the increased accuracy, psychological impact, affordability, reliability, and penetrating capacity of missiles for conventional missions. This integration of missiles into operational arsenals is leading to the dissemination of both ballistic and cruise missiles to a number of countries. About 30 countries, as well as non-state actors currently possess ballistic missiles, with the most recent acquirers being Azerbaijan, Algeria, Bahrain, Qatar, and Myanmar. More states are developing and producing cruise missiles, with new domestic programs ongoing, for instance, in Australia and Brazil.

As a weapon of choice for delivering WMD, missiles can be destabilizing weapons even when they are coupled with conventional warheads, due to their short flight time, ability to elude defenses, escalatory nature, and propensity to put civilian population at risks.

In that context, controlling and regulating missiles is an important objective, and some norms and instruments already exist to that end. This paper recalls the different approaches used to limit the spread of missiles and decrease their destabilizing effect. It assesses the effectiveness of such mechanisms and identifies the challenges they are facing. It ends by listing the priority steps that could be taken to strengthen the current missile and arms control regime.
Various Approaches to Reducing the Risks Posed by Missiles

Reducing the Number of Players: Initiatives in the Field of Missiles

As with WMD, attempts have been made to restrict the number of countries possessing missile technologies. However, these attempts have not taken the form of a treaty. As ballistic and cruise missiles are perceived by nuclear-weapon states as indispensable delivery vehicles for their nuclear weapons, these states refused any international convention prohibiting them (Delory 2011), even if this idea was floated around at the end of the Cold War (Lumpe 1993). On the other hand, framing a double-status instrument, similar to the NPT, would have been unacceptable politically. The difficulty of promoting a treaty in which some states are asked to relinquish capacities that other can retain appeared rapidly in the history of the NPT (Tertrais and Maitre 2020), and it seemed obvious that a comparable instrument dealing with missiles would not gather the support of a majority of UN member states.

In that context, the main instrument used to limit the spread of missiles has been, since 1987, the Missile Technology Control Regime (MTCR). The MTCR was negotiated and adopted in the framework of the G7\(^1\) under the guidance of the Reagan administration, which expressed its concern at the beginning of the 1980s about the spread of missile and launcher technologies (Ozga 1994). It expanded its initial restricted membership with efforts to encompass the main missile technology producers. By the mid-1990s, most European countries had joined. In 1995, a major milestone was reached with the formal adherence of Russia, but also of countries such as Brazil and South Africa. The latest major country admitted to the MTCR was India, in 2016.

The Wassenaar Arrangement, formally established in 1996, also plays a role in this framework, as it contains a proviso to curb the export of missiles, propulsion systems, and specially designed testing and production equipment. The Arrangement has 42 participating states committed to promoting transparency and responsibility on export control practices, in particular with regard to dual-use items such as rocket engines (Brockmann 2020).

Since the 1990s, the implementation of this export control mechanisms played a role in hampering the development of long-range capacities in South Korea and constrained the development of national ballistic missile or space programs in Argentina, Iraq, and South Africa (Delory 2011). In particular, one of the main achievements of the MTCR has been the formalization of an accepted norm making the transfer of missiles capable of delivering WMD illegitimate. With the exception of North Korea, this norm has been globally accepted and mostly respected by the main countries producing these systems, even when they remained outside of the regime.

It was reinforced in 2002 when MTCR partners opened negotiation to the rest of the international community on what became known as the Hague Code of Conduct against ballistic missile proliferation (HCoC). Requiring transparency on ballistic missiles that can carry WMD as well as space launchers, this instrument brings legitimacy to the principle of nonproliferation by calling its members to exercise vigilance in any transfers of materials or technologies that could contribute to the proliferation of ballistic missiles.

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\(^1\)Canada, France, the Federal Republic of Germany, Japan, Italy, the United Kingdom and the United States.
The addition of delivery vehicles into the efforts to curb WMD proliferation has also been visible at the United Nations, with multilateral decisions taken to try to halt the development of missile programs in country of concern. These have targeted North Korea in particular, with the adoption of United Nations Security Council (UNSC) Resolution 1695 in 2006, which demanded, “given the potential of such systems to be used as a means to deliver nuclear, chemical or biological payloads”, that North Korea “suspend all activities related to its ballistic missile programme”, (UNSC 2006a). More recently, Resolution 2397 condemned the test of an intercontinental ballistic missile (ICBM) and imposed a set of sanctions designed to put constraints on the North Korean nuclear and missile program (UNSC 2017).

With regard to Iran, Resolution 1696 was the first to link the Iranian missile program with its nuclear activities (UNSC 2006b). Resolution 1929 reaffirmed the decision to “constrain Iran’s development of sensitive technologies in support of its nuclear and missile programmes” and declared that Iran “shall not undertake any activity related to ballistic missiles capable of delivering nuclear weapons, including launches using ballistic missile technology, and that States shall take all necessary measures to prevent the transfer of technical assistance to Iran related to such activities” (UNSC 2010).

More globally, as early as 1991, the UNSC made official the link between WMD and their delivery vehicles in its Resolution 687, which put an end to the First Gulf War. As it called Iraq to dismantle all WMD programmes and missiles with a range greater than 150 km, it noted that the Iraqi disarmament “represented steps towards the goal of establishing in the Middle East a zone free from weapons of mass destruction and all missiles for their delivery” (UNSC (United Nations Security Council) 1991). This connection was also recognized in Resolution 1540 (2004). This legally binding text places obligation on all states to take appropriate measures to prevent the proliferation of WMD and their delivery vehicles to non-state actors. Means of delivery are defined in the resolution as “missiles, rockets and other unmanned systems capable of delivering nuclear, chemical, or biological weapons, that are specially designed for such use” (UNSC 2004). This resolution is arguably the mechanism that has had the most impact in strengthening the national measures taken by states to address the question of missile proliferation, especially for states with no or limited capacities in this field. Under the pressure of the Resolution 1540 reporting mechanism, these states have been pushed to adopt export-control measures on missile technologies and dual-use items such as navigation systems or truck parts used in missile transporter-erector-launchers and other applications. At the normative level, the resolution has also played an important role. It formally put means of delivery in the categories of WMD, such as nuclear, chemical, and biological weapons and emphasized the need to control them and prevent their dissemination.

Without any global regime prohibiting missiles and their proliferation, several complementary mechanisms have been trying since 1987 to stop the dissemination of missiles capable of carrying WMD, especially on the ballistic side, considering that they are key instruments in the operationalization of a nuclear, biological, or chemical weapons program (Brockmann 2020). In parallel, measures have been adopted to reducing the existing arsenals of delivery vehicles.
Limiting the Arsenals: Arms Control and Delivery Vehicles

As the United States and the Soviet Union agreed on the necessity of arms control measures capping arsenals and later reducing the volume of weapons, the focus immediately turned to delivery vehicles launchers for different reasons. Ballistic missile launchers, in particular, appeared as a countable, and tangible item for which quantitative limits could be established. Because of their size and deployment characteristics, verifying limits on launchers could be envisaged initially only through national technical means and later through mutually acceptable declaration and inspection procedures. This approach avoided the contentious issue of having to control the elimination of nuclear weapons per se, which would have created important verification challenges in terms of national security, confidentiality, and confidence in the process (Maitre 2020a).

The negotiation of limitations on launchers has therefore served as an indirect way of reducing the number of deployed missiles and therefore nuclear weapons. With the end of the Cold War, the adoption of the Strategic Arms Reduction Treaty led to major reductions in the number of deployed intercontinental and submarine-launched ballistic missiles (SLBMs), which were aptly interpreted as reductions in the nuclear arsenals of the two major nuclear powers, as those systems were purely dedicated to the nuclear deterrence mission. Interestingly, while some missiles were destroyed ostensibly in front of cameras, others were converted to satellite launchers (Gaillard-Sborowsky, Sourbes-Verger, and Tortora 2018). The elimination of the weapons themselves and their material took place according to national processes or bilateral cooperative endeavors and sometimes were not completed until years after the treaties’ entry into force (Nnsa 2009).

New START, signed in 2010, pushed this logic even further. The treaty imposes quantitative ceilings on ICBMs, SLBMs, and strategic bombers, as well as strategic warheads. But this latter limitation is not verified empirically; it is assumed by counting the reentry vehicles mated to each missile.

Going beyond Nuclear Arms Control?

Because it paradoxically – but understandably – focused on missiles and their launchers, strategic arms control between the United States and Russia has eventually encompassed limitations on systems regardless of the nature of the warhead. This phenomenon was especially visible with the signature of the Intermediate-Range Nuclear Forces (INF) Treaty in 1987, which, although conceived to limit nuclear-capable systems, is in fact not limited to missiles mated to nuclear warheads. The treaty requires the destruction of all ground-based ballistic and cruise missiles with a range between 500 and 5,500 kilometers (km). In these ranges, ballistic and cruise missiles may in theory be produced and deployed as conventional weapons, especially because of the technical advances that have led to an increase in the precision of the missiles of all major producers. This option has already been demonstrated by China, which possesses a range of intermediate-range weapons thought to be dual-capable. While still constrained by the INF Treaty, Russia apparently developed conventional intermediate-range systems (cruise missile 9M729/SSC-8) that were illegal under the treaty, prompting the United States to withdraw from the treaty in 2019. Both countries are currently acquiring medium- and intermediate-range conventional weapons. The
United States is expected to deploy weapons with ranges above 500 km, for instance the Precision Strike Missile, which has now been capped at 499 km but could be redesigned for greater ranges in the future (Rempfer and Gould 2020). Deploying the Tomahawk cruise missile on ground launchers is also being explored. The Tomahawk is currently a sea-based weapon with a range estimated between 1,250 and 2,500 kilometers. New prototypes of cruise or ballistic missiles of intermediate ranges could also be developed as alternatives (Reif 2020).

In retrospect, these developments show how arms control agreements have managed to constrain the development of missiles, as such, with no regard to their associated warheads. However, the violations of the INF treaty and the mutual withdrawal from it can in part be explained by the refusal of its parties to accept restrictions on the development of conventional weapons deemed useful by their militaries (Pasandideh 2019). In this context, it may seem unlikely that the proposition made in the 1990s and early 2000 to negotiate a multilateral INF Treaty, or to move forward on the creation of an instrument controlling missiles regardless of their purposes, discussed in particular within UN groups of experts, may come to fruition in a foreseeable future. On the contrary, renowned experts have suggested that arms control objectives could be best achieved by refocusing on systems capable of delivering WMD (Gottemoeller 2019). Under those more restrained definitions, not only arms control measures dealing with means of delivery but also disarmament initiatives could be imagined, following several historical examples.

**Disarmament and Delivery Vehicles**

In the last years of the Cold War, and in the wake of the arms control agreements mentioned above, the United States and Russia got rid of some missile systems seen as being in excess of requirements, but the focus remained on nuclear-capable systems. Thus, the United States declared in 1991 that it would eliminate a number of nuclear-armed delivery vehicles, such as cruise missiles deployed on ships and submarines and short-range ballistic missiles (SRBM). On the Russian side, nuclear warheads were also dismantled, while delivery vehicles may have been preserved for conventional purposes (Arms Control Association 2017). The two countries were joined in this initiative by other countries such as France, which eliminated its land-based ballistic missiles around 1996.

In a very different context, other delivery vehicle programs have been curbed or eliminated since the Cold War. Thus, the countries that decided to unilaterally renounce the acquisition of nuclear weapons or to forgo their nuclear arsenals also decided to abandon their ballistic missile ambitions. It is notably the case of Brazil and Argentina, which worked to develop ballistic missile launching technologies. While space launch programs had been initially used to kick-start or disguise these programs, these countries eventually attempted much later to convert their know-how in the framework of civilian launching programs. South Africa was a unique case as it destroyed its nuclear warheads and in parallel halted its ballistic missile program, under strong pressure from the United States. Finally, Belarus, Kazakhstan, and Ukraine all eliminated or transferred to Russia the strategic ballistic missiles and cruise missiles stationed on their territories as they decided to join the NPT as non-nuclear-weapon states, while other Warsaw Pact
countries, such as Bulgaria, the Czech Republic, East Germany, Poland, Romania, and Slovakia, phased out their Soviet-origin arsenals (notably OTR-23 Oka/SS-23 and Scud-derived systems).

Two other missile programs were dismantled in the 1990s and 2000s. After its defeat in the First Gulf War, Iraq was required by the UN Security Council to dismantle all its WMD, including its delivery vehicles with a range exceeding 150 km. That group comprised Scud-B systems and other domestically produced short-range systems (UNSC (United Nations Security Council) 1991). This operation was mostly conducted by the Iraqi government, but the lack of evidence concerning the actual destruction of weapons and infrastructure led UN inspectors to hunt for remaining capabilities and related technologies during the decade of WMD search in the country (Federation of American Scientists 1998).

Finally, Libya was also asked by the United States to renounce the majority of its missile arsenal as it decided to close its WMD programs. Some of the key parts were sent to the United States as early as 2003, but the Gaddafi regime proposed to convert the remaining systems to shorter-range weapons. Negotiations failed and Tripoli eventually agreed to a protocol to ensure the destruction of the missiles (White House 2004). However, the latter stages of the process were not completed before the end of the regime and remaining Scuds were thought to be in the possession of various armed groups in the country. Due to the absence of maintenance and poor storage conditions, these lingering weapons are thought to be out of service by now.

**Managing the Risk through Confidence-building Measures**

As these various attempts at controlling or dismantling WMD means of delivery have of course not led to their complete elimination, confidence-building measures (CBMs) have been seen as an attractive option to limit the potentially destabilizing impact of these systems. Historically, these measures have been implemented mostly at the bilateral level, with the objective of limiting the risk of unintentional escalation. A major risk that the ballistic missile powers identified and empirically verified was that ballistic missile tests could be misinterpreted as attacks. The powers therefore felt the necessity to inform their counterparts of their scheduled tests ahead of time.

The earliest mechanism of this nature, signed in 1971 by the United States and the USSR, concerned missiles flown in the direction of the opposite party and beyond the national territory of the launching state (UN 1971). In 1988, the two countries expanded that measure with a more detailed procedure for notification of ICBM and SLBM launches in the framework of the Nuclear Risk Reduction Centers (US Department of State 1988). Because of their similarity to ballistic missiles, space vehicles have slowly been included in these transparency efforts. In 2000, another agreement was signed between Moscow and Washington. It required both parties to send pre- and/or post-launch notification for the launch of ballistic missiles with a range exceeding 500 km and for most space-launch vehicles (SLV) (US Department of State 2000).

These mechanisms were to some extent replicated between two other nuclear dyads. First, such a transparency measure was part of a list of CBMs adopted by India and Pakistan in the 2000s. This agreement was signed in 2005 (NTI 2004) and has been extended since then. Interestingly, it deals with all kinds of ballistic missile tests but also
imposes restraints on the location test sites, impact, and trajectory to ensure they do not get too close to the border between the two countries (Stimson 2005). Second, Russia and China agreed to a mutual pre-notification system in 2009 (Champlin 2009), which was renewed in December 2020 (Global Times 2020).

Limiting the inherent risk posed by WMD means of delivery is also at the root of a multilateral HCoC. This one-of-a-kind CBM aims at universality and has attracted 143 subscribing states at this stage. While countries agree to show restraint in the development and vigilance in the transfers of ballistic missile technologies, this text also contains three transparency mechanisms. First, subscribing states are invited to share each year an annual declaration on their ballistic missile and SLV policy, whose level of details is up to states. Second, countries must send pre-launch notifications for their ballistic missiles tests and SLV launches. Finally, states are invited, on a voluntary basis, to organize visits of their SLV launching pads and testing grounds, if they possess any—a CBM which has been implemented in particular by France, Norway, and Japan (Héau and Maitre 2020). It must be noted that none of these mechanisms has taken into consideration the development of cruise missiles.

Transparency and accountability have also been pursued by two additional mechanisms that are more inclusive in their scope, namely the United Nations Register of Conventional Arms and the Arms Trade Treaty (ATT). Both instruments have the ability to include all types of missiles in their scope. The ATT requires states to maintain a national control system to regulate exports of weapons, and the UN Register requires them to report annually exports and imports of major arms.

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Occasionally considered to be the “fourth WMD”, means of delivery are unique insofar as they are not regulated by a broad and universally recognized treaty. However, different frameworks exist to avoid the dissemination of these systems, reduce their volumes, and limit the risk they pose. These various measures and regimes are currently facing challenges that put their relevance in question and may require adaptations and a change of perspective regarding their role and their effectiveness in controlling missiles.

**New Challenges and Current Dynamics**

**Delivery Vehicles and Conventional Uses**

One of the main factors complicating any attempts to frame and implement arms control on delivery vehicles is the fact that depending on their characteristics, delivery vehicles belong to very different kinds of weapons. Thus, long-range heavy missiles have traditionally been associated with WMD, as they had little use as conventional weapons. But short-range systems, especially cruise missiles, have been used in many conflicts, and their possessors do not consider that these weapons should be submitted to the same confidence-building, nonproliferation, or arms control measures.

Among these weapons that can be used for conventional strikes, cruise missiles have been especially developed and used by Western countries and Russia. Thus, the Tomahawk subsonic system, whose range is between 1,500 and 2,000 km, may have been used about 2,000 times by the United States and British armed forces in Iraq, former
Yugoslavia, Afghanistan, Somalia, Libya, Yemen and Syria since 1991. France and the United Kingdom used the Storm Shadow/SCALP-EG in various combat operations, especially in Iraq, Libya, or Syria. During the Syrian war, Russia made use of its air-launched Kh-101 and sea-launched Kalibr missiles, and France used a similar system named MdCN in Syria (Delory, Maitre, and Masson 2019; Navy Recognition 2018).

On the ballistic side, tactical missiles are also designed as conventional weapons for use on the battlefield, and their employment has dramatically increased in recent years as systems have proliferated to states and non-states actors. On the US side, the main system is the quasi-ballistic MGM-140 Army Tactical Missile System, a weapon operated by the Army and fired from a multiple rocket launcher. Hundreds of missiles have been fired since the first use during the First Gulf War in 1991. As a replacement for systems developed for WMD and conventional use as early as the 1950s and maintained by the Soviet Union during the Cold War, Russia has developed the dual-use SS-26 (Iskander) that may have been used in recent years in Syria (Roblin 2021). This system or an export version may have been used in the 2020 war between Armenia and Azerbaijan (Kasapoğlu and Özkaraşahin 2021). A number of other states are producing and/or importing these precise SRBM, in particular China, Turkey, Iran, South and North Korea, as well as a number of other countries in the Middle East (Delory 2020).

But in this region, the drivers of missile proliferation are also non-state actors. Hezbollah and the Houthis have acquired systems from Iran and/or Syria. The Houthis are now thought to possess their own assembly capabilities and are frequently using their missile arsenals in strikes on Yemeni and Saudi territory (Masson 2018). While figures are difficult to establish with certainty, around 40 ballistic missile strikes took place worldwide in 2020, including around 30 by the Houthis, and the rest by other actors (Iran, Armenia, and Azerbaijan).

This frequent use and increased reliance on conventionally armed cruise and ballistic missiles makes any attempt to create global regulations for these technologies extremely difficult. Existing agreements have tried to exclude many of these tactical conventional weapons from their scope. Thus, the MTCR relies on technical criteria and focuses only on weapons with a range of more than 300 km and a payload of more than 500 kg. These criteria were inspired by the range of the Soviet SS-1c Scud missile and the theoretical weight of a nominal first-generation nuclear warhead (Delory 2020). Exporting states have adapted to these limitations and have been able to export conventional weapons with a range situated below the 300 km threshold, sometimes by adapting their domestic version. For example, the SS-26 Iskander-E, proposed for export and acquired by Algeria and Armenia, has a shorter range and a lower payload than the Russian SS-26 Iskander-M.

UNSC Resolution 1540 and the HCoC adopt a different approach, as they do not state technical criteria, but focus on the capability of the weapons. Thus, Resolution 1540 defines means of delivery as “missiles, rockets and other unmanned systems capable of delivering nuclear, chemical, or biological weapons, that are specially designed for such use” while the HCoC systematically mentions in its scope

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2 The United Arab Emirates may also have been targeted, in Abu Dhabi or at sea.
3 Figures compiled by the of staff of the Fondation pour la recherche stratégique (FRS) from news agency reporting.
“missiles capable of delivering weapons of mass destruction”. The two formulations may differ, but the result is that short-range systems (under 300 km) may not be considered by all states as falling under the scope of the HCoC and their launches may not be systematically pre-notified\textsuperscript{4} Likewise, Iran has not been formally accused of violating Resolution 1540 as the missiles transferred in particular to the Houthis could not be proven to have been “missiles, rockets and other unmanned systems capable of delivering nuclear, chemical, or biological weapons, that are specially designed for such use” (UNSC 2019). Concerning the specific UNSC resolutions on Iran and North Korea, missiles “capable of delivering WMD” are widely interpreted to mean missiles covered by the MTCR.

These practices and restrictions mean that arms control and nonproliferation mechanism has drawn a distinction between delivery vehicles designed to carry tactical conventional weapons and those capable of carrying WMD or designed to do so. Indeed, the dissemination of these latter systems, their deployment and their testing can have destabilizing effects for the international community. However, this clear division has long been questioned, especially with regard to the delivery of chemical and biological weapons, for which a much smaller payload may still have disproportionate effects. Moreover, the miniaturization of nuclear warheads means that missiles that are below the MTCR 300 km/500 kg thresholds could in theory have a WMD purpose. The Pakistani Haft-IX/Nasr is supposed to have a range of less than 70 km and carry a payload of 400 kg, but its nuclear purpose has been clearly stated (Missile Defense Project 2016). This is also true for cruise missiles, which are completely excluded from the scope of the HCoC (Delory, Maitre, and Masson 2019). This loophole was recognized by MTCR partners in the early 1990s with the adoption of new item advising a strong presumption of denial for systems with a range of 300 km and a low payload if the system is thought to be acquired to deliver WMD (MTCR 2019).

On the other hand, the increased precision of systems means that some medium- to long-range missiles (cruise or ballistic) may be developed purely for conventional missions to increase deep strike capabilities in conflicts. This conventional use of long-ranges missile was initially promoted within the US (Conventional) Prompt Global Strike program, with various options explored to produce and deploy such a capacity (Congressional Research Service 2020). In a more limited way, it is displayed by South Korea, which has been allowed by Washington to produce missiles with a range exceeding 800 km (Wright 2021). With the demise of the INF Treaty, the question of whether systems produced with the purpose of carrying conventional weapons and with a range above 500 km should be considered by arms control mechanism—and if so, how—is far from being resolved. As these weapons may compose a substantive part of the Chinese arsenal, and as they will continue to grow in the US and Russian arsenals, it might become especially important to decide if nonproliferation and arms control measures should focus on WMD delivery vehicles or encompass all systems. If controlling the means of delivery for WMD is the priority, it may be necessary to rethink a way to define them.

\textsuperscript{4}Interviews with representatives from HCoC member states, summer 2020.
**The Impact of New Technologies**

A second element that may call into question the relevance of current nonproliferation and arms control mechanisms regarding missiles is the emergence of new technologies in the field. Indeed, some instruments may have the flexibility necessary to adapt and encompass these technological innovations, while others may be restricted to existing weapons and configurations.

Hypervelocity is one of the evolutions that currently is receiving the most scrutiny (Barrie 2019). The concept is complex, as it encompasses several key technologies currently being explored following very different prototypes. Hypersonic speed is defined as exceeding Mach 5 (five times the speed of sound) for missiles whose trajectory remains within the atmosphere. Following this criterion, traditional ballistic missiles are not hypersonic weapons, even if any MRBM, IRBM or ICBM, reaches speeds above Mach 5 during reentry, since they do not operate most of their flight within the atmosphere (Tracy 2020a). The difference with the systems referred to as “hypersonic” is therefore in the trajectory, which is not ballistic, and thus offers greater maneuverability and potentially makes these weapons less vulnerable to anti-missile systems (Lele 2017).

Two types of technologies are being developed today. First, hypersonic gliders are propelled up to a certain altitude by a rocket and then released to glide toward their target at hypersonic speed. Second, hypersonic cruise missiles are relying on a scramjet engine (Acton 2018). This second technology is still in development, in particular in the United States, although Russia has conducted several successful tests of its 3M22 Zircon scramjet-powered anti-ship cruise missile. Gliders are more mature, but their technical features differ. The United States is investing in vehicles that may be deployed with the Navy, Air Force, and Army. Recent test flights have proved the ability to fly to a range of up to 4,000 km. In one of the latest test of March 2020 the glider (C-HGB) was coupled with the Strategic Target System (STARS) booster (a rocket built using old Polaris SLBM) that is responsible for the launch of the vehicle (Tracy 2020b).

China’s efforts are mostly centered on the DF-17, a medium-range ballistic missile coupled with a hypersonic glide vehicle. The specifications of this weapon are not known, but the missile has been deployed and tested at least 14 times (Missile Defense Project 2020).

Russia is also rather advanced in the deployment of hypersonic weapons. Its programs are especially emphasizing the capacity to deliver a nuclear warhead. The operational and deployed Avangard system is a combination of a glider and a ballistic booster (SS-19 Stiletto ICBM today and the Sarmat ICBM in the future). With an intercontinental range, it is not known for what distance the glider is able to fly independently from the booster. The 3M22 Zircon/Tsirkon hypersonic cruise missile would have a reduced range but would also be able to carry a nuclear warhead (Karnozov 2019).

Determining for how long the weapon is gliding independently from the booster matters for strategic considerations, and is also important in terms of arms control and nonproliferation. Because the Avangard relies largely on a traditional ballistic launcher and is a strategic weapon, Russia has decided to count that system as a land-based item under New START, which was extended in 2021 (Trevithik 2019). But other hypersonic weapons, which are designed for conventional purposes, particularly in the United States, and do not use a booster that falls under the scope of New START, are not at this stage
counted under the mechanism (David 2020). In fact, negotiators of the treaty in the United States were compelled by Congress to ensure that vehicles whose flight was mostly non-ballistic were not included in the treaty. As Washington was in the middle of developing some nonstrategic systems, it did not want any constraints on these technologies, and the Senate insisted on the fact that these boost-glide weapons should not be counted under the treaty (US Department of State 2010)\(^5\) While Russia rejected this unilateral interpretation, it did not raise the issue officially, as the United States has not deployed any of these systems so far (Tracy 2020a).

The same debate may apply to regimes such as the HCoC. As ballistic launches must be pre-notified to other subscribing states, a test of a hypersonic glider launched from a land-based ICBM or similar rocket would fall within the spectrum of the HCoC (UNIDIR 2019). The Avangard in particular would be considered in this light and its tests have probably been pre-notified (Delory, Maitre, and Masson 2019). But if the booster is not a ground-based missile, states may feel that they are not obliged to pre-notify tests under the regime, as hypersonic glide vehicles do not fly on a ballistic trajectory (FRS 2021).

This is also the case concerning hypersonic cruise missiles, as of course the Code only takes into account ballistic systems. While these weapons are not yet deployed, it appears that they would not currently fit within the existing arms control framework beyond the MTCR. The status of air-launched systems would also depend on the aircraft that is selected to carry them, as only some of them are considered strategic and therefore fall within the spectrum of New START, for instance (Acton and Vaddi 2020).

Concerning export controls for these systems, the existing arrangements, and in particular the MTCR, are adequate to control most of these delivery vehicles, which should fall within the lists of controlled items. In particular, the MTCR covers reentry technologies, propulsion, and some materials. However, the regime would here again suffer from its limitations (300 km/500 kg criteria). The MTCR has not resolved specifically the question of boost-glide systems and the regime’s adaptation to the components and technologies involved (UNIDIR 2019). The Wassenaar Arrangement also has a rather broad control list that would take into account a number of critical components produced for a glider or hypersonic cruise missiles, but has not specifically updated its lists in that regard.

Arms control and nonproliferation efforts on missiles are not only affected by military innovations, but also need to take into consideration some civilian evolutions. Ballistic missiles and space launchers in particular share a number of technologies, which lead export control regimes to focus on ballistic missiles and space launch vehicles in a similar way. Among the key trends characterizing the space industry today is the miniaturization of satellites. The attractiveness and capabilities of small satellites create a business rationale for developing some smaller launchers, able to put payloads of 100 to 500 kg into lower orbits. Small launchers are cheaper than heavy-lift SLVs such as the European launcher Ariane V, and they can be developed by private companies as well as new spacefaring countries. Interestingly, the development of smaller rockets increases the commonalities

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\(^5\)“Nothing in the New START Treaty restricts United States research, development, testing, and evaluation of strategic-range, non-nuclear weapons, including any weapon that is capable of boosted aerodynamic flight.” (US Department of State 2010).
between ballistic missiles and civilian launchers, starting with the size: a Minuteman III is 18 meters high, comparable to the Chinese launchers OS-M1 or Ceres-1 which have a height of 19 meters (Maitre and Moreau-Brillat 2022). In terms of technologies, an important element is the use by some of these light launchers of solid propellant, which makes them more closely resemble ICBMs. The linkage is obvious for the projects that are directly derived from decommissioned ICBMs, such as Minotaur I, derived from the American Minuteman ICBM, or the Russian Rokot, from the UR-100 N (SS-19). In addition to technical features such as propulsion, guidance systems, and material, there are similarities in industrial processes (Pasco and Delory 2017). Thus, Rocket Lab has renounced the traditional SLV business model of on-demand production and aims at mass production by adapting processes usually used for the manufacturing of missiles, blurring the line between the two kinds of rockets (Lavars 2018). Finally, the launching methods are also becoming more diversified, with the use of land-transportable, land-mobile or airborne launchers, which also increases the similarity with military assets.

While these evolutions have not led to major missile proliferation so far, the dissemination of know-how and dual-use materials linked to the development of small launchers is an additional challenge to nonproliferation regimes. Additionally, efforts to bolster nonproliferation mechanisms, and in particular export controls, must not impinge on the right to access space. Ensuring that right may create operational limitations on the implementations of some measures.

That being said, countries are also investing in the space domain for military purposes. Weapons such as anti-satellite kinetic weapons create new missions for ballistic missile technologies. While these weapons are not new, they are so far not controlled by any arms control agreements and their development by more countries may create uncertainty and instability. The HCoC can be used to pre-notify these tests, but a more specific regime may be required to ensure that states possessing these weapons adopt responsible behaviors (UNIDIR 2020).

Finally, as mentioned above, the progress made in recent years to make ballistic as well as cruise missiles more accurate, reliable, affordable, and accessible tends to increase their attractiveness as battlefield weapons. Due to these developments, visible on shorter-range missile but increasingly on longer-range missiles as well, many states perceive these systems as operationally useful weapons, more resilient and capable than air strike components (Delory 2015). This trend has already been reflected by the rising number of uses in conflicts since the beginning of the 21st century. As it continues, especially in relation to delivery vehicles with very long ranges, it will be a complicating factor for nonproliferation and arms control issues as it may redefine the notion of “strategic missile” while making states less inclined to display transparency on weapons used frequently in the theater (Hoffmann 2021).

**The Modification of Production Patterns**

A last challenge for controlling missiles is the evolution of production patterns, a problem especially noticeable in nonproliferation and counterproliferation efforts.

In particular, some proliferating states have acquired substantial autonomy in the development and manufacturing of systems, which means that, unlike countries such as Argentina and Brazil in the 1990s, they are to a large extent less affected by international
efforts to deprive them from materials, technologies and know-how. This tendency has in particular been seen in North Korea and Iran, and these countries are moving from a rudimentary missile production capacity to a more advanced capacity, enabling them to develop domestically designed systems with greater accuracy and range. This is enabled in particular by the ability to produce alloy and composite fibers but also more effective propellants and maneuvering technologies (Delory 2019). The increasingly autonomous development of these programs is a key dent in the effectiveness of targeted efforts such as UN sanctions on the development of ballistic missiles and limits the tools available to curtail the spread of these systems (Delory 2017).

This loophole is highlighted by the fact that these two countries have altered the dynamics of the proliferation of missile parts and technology. Historically, Pyongyang has exported Scud-derived technologies to countries such as Pakistan, Egypt, Yemen, Libya, Syria, Iraq, and Vietnam (Mistry 2003). More recently, Iran has been involved in the dissemination of heavy guided rockets and ballistic missiles to Syria but also to non-state actors such as Hezbollah in Lebanon and the Houthis in Yemen (Williams and Shaikh 2020). Here again, recipient of missiles has increasingly been able to assemble and even produce missile parts on its territory, with the support of sponsors, which has thwarted international efforts to intercept shipments and implement embargoes imposed by the UNSC. While the Houthis are still largely reliant on Iran for key expertise and material supply, the possibility that they may slowly internalize some processes and manufacturing tasks may increase the difficulty of countering this proliferation of strike systems (Masson 2018).

This development of domestic capabilities is enabled by a number of practices, such as the shipment of raw materials and smaller parts, but also a number of dual-use parts and machinery that are less easy to identify for export control authorities (Xu and Hanham 2021). Digitalization of the conceptual phases enables intangible transfers, while the increased performance of computers and software is used to improve the development of new designs and reduce the need to conduct on-site tests (Xu and Hanham 2021). These developments are contributing to the reduction of the footprint of missile programs and tend to make the dissemination and exports of technologies easier.

Another important element in that vein is the development of advanced additive manufacturing. The importance of this technology has already been demonstrated in the civilian sector as Rocket Lab announced that parts of its Electron rocket would be produced through additive manufacturing (Winick 2019). In 2015, the weapon manufacturer Raytheon tested a design produced 80% through additive manufacturing (Raytheon News 2015). Using this technology could lower the cost of a missile program as well as, in the long term, the expertise required (Shaw 2017).

As countries with limited industrial infrastructure may be able to print key parts, traditional export control and nonproliferation mechanisms may be deeply challenged and a change of paradigm may be necessary to avoid them becoming irrelevant (Brockmann and Bauer 2017). While the electronic files used for storing and describing MTCR-controlled items (build files) are already listed in the regime’s annex, agreeing on ways to include 3D printing machinery able to manufacture relevant pieces for missile parts in export control regimes such as the MTCR or the Wassenaar Arrangement is especially difficult, as the bulk of these machines have many civilian
applications. Controlling raw material, particularly the metal powders required for the manufacturing, entails the same difficulties. In that context, propositions made by several partners to control some of these items have to this day failed (Brockmann and Bauer 2017).

A slightly less controversial avenue is the control of build files. However, the problem here concerns implementation, as these transfers are not physical. At this stage, the emergence of additive manufacturing therefore emphasizes the difficulty in controlling intangible transfers of technologies, which is already recognized by a regime such as the MTCR, but has historically been a weakness of the regime (Idiart 2017).

Finally, this virtualization of processes and of transfers may increase the risks of involuntary transfers, provoked by cyber-intrusion and cyber-espionage.

Renewing Arms Control in the Field of Missiles

Limited Objectives for Nonproliferation

With regard to the objective of limiting the spread of ballistic missiles, the adoption of a binding global agreement remains politically unrealistic at this stage. Given the spread of short-range ballistic and cruise missiles, which are now in the arsenals of more than 40 countries, any regulations or constraints on the acquisition or development of conventional missiles is bound to fail. In that context, preserving the focus on the means of delivery of WMD may be a prerequisite for any agreement to be accepted by the main stakeholders.

Limiting the spread of WMD-capable missile technologies is therefore bound to remain the primary goal of the MTCR. This regime has shown a level of effectiveness and flexibility, but it has also shortcomings that may be addressed in order to bolster the system.

First, given the multiplication of the number of countries mastering advanced technologies in this domain, it will only be considered as a fully effective regime when most potential suppliers agree to respect its provision and to display an adequate level of commitment to the principles of the regime. The ability of the HCoC to attract 143 subscribing states to this day, and to be widely supported at the UNGA, even by non-subscribing states, has contributed to solidifying the legitimacy of the nonproliferation norm for delivery vehicles that is underpinning export control regimes. But partners will have to conduct outreach efforts to show the importance of their work and to try to convince as many actors as possible to implement similar control lists.

Second, as mentioned, the focus on unmanned delivery systems capable of delivering WMD seems realistic and relevant in the current context. However, the traditional assumptions and technical criteria may be less pertinent. The case of South Korea shows that long-range land-attack missiles can be purely conventional while the Pakistan case illustrates the possibility of putting small nuclear warheads on close-range ballistic missiles. Adopting a case-by-case approach instead of the very strict 300 km/500 kg criterion may be more relevant, but would possibly entail the creation of intrusive verification measures. In some cases, proving that missiles have a conventional role may appear simple if the recipient countries are not suspected of having or seeking WMD capabilities and are rather open and
transparent about their practices. The situation would be more difficult in the event of undeclared WMD arsenals, especially the possession by some countries of chemical weapons that could in theory be mated with smaller-payload and lesser-range missiles.

Third, the regime would need to continue its adaptation to reflect new systems and new production processes. Concerning the latter, technical work to think about the best ways to revise the control lists should continue in the relevant official framework. Technical experts are essential to assess the current loopholes but also to warn against unintended consequences of regulations and propose options that can be realistically implemented. But their proposals need to be studied seriously by diplomatic and political teams, who are sometimes daunted by the technicality of control lists. While it is impossible to imagine a regime such as the MTCR trying to adopt controls for all additive manufacturing machinery implied in the production of missile parts, it might be possible to control some machines with key characteristics, along the lines of propositions already made – but refused – by partners of the Nuclear Suppliers Group or the Wassenaar Arrangement (Brockmann and Bauer 2017).

Concerning the strengthening of the mechanism against intangible transfers of technology, applied in particular to build files for 3D printing, partners could also envisage some modifications in the control list, but a more effective route may be national implementation. On this, a special focus could take the form of dialogue with actors from private industry and awareness building on the dual use of various designs (Brockmann and Bauer 2017). Finally, inadvertent dissemination of designs and technologies can be tackled by using known cybersecurity techniques, but also more innovative approaches, such as the blockchain technology, which the US Navy already is using (McCarter 2017).

On hypersonic technologies, export controls already encompass most critical technologies, but the adoption of clearer guidelines may be useful. Thus, for instance, proposals have been made to MTCR partners to display a strong presumption of denial on “complete hypersonic glide vehicles, complete hypersonic cruise missiles” and their warheads. Concerning “scram-jet and other hypersonic engines, fuels for hypersonic use, materials and thermal protection hardware for hypersonic flight, sensors navigation and communication items for hypersonic flight, flight controls and ground simulation and testing for hypersonic systems”, these proposals advise states to assess applications case by case (Siddhartha 2017). This type of expansion and clarification would not necessarily bring about a profound change in the practices of partners, but it would re-open the question of the regime’s focus on WMD-capable systems.

While these measures may appear to be limited, the design of a two-tiered mechanism, with a trilateral effort by the United States, Russia, and China to prevent other countries from gaining access to this technology – as proposed by a widely circulated study published by the RAND Corporation – may be out of reach in the foreseeable future by lack of political support (Speier et al. 2017). Criticism of such a measure has already been published (Siddhartha 2017), especially from countries such as India, and the three countries that are currently leading the game do not seem to be eager to restrict the access of their allies and partners to these technologies, given that the potential applications of these systems go well beyond the delivery of WMD.
More modest proposals for banning the testing of these systems, which followed the logic of the Comprehensive Nuclear-Test-Ban Treaty and would be a measure to curb both the dissemination of systems and their qualitative development in countries that already have them, have also been described as unfeasible now (Bulletin of the Atomic Scientists 2015). In that context, the best to hope for would be the incorporation of these systems into existing and future arms control mechanisms and the implementation of adequate CBMs to limit the risks posed by these weapons for strategic stability.

**Revising the Scope of Legally Binding Arms Control**

The major powers do not plan to end their reliance on unmanned deep strike systems. On the contrary, they may be developing their arsenals of these weapons quantitatively and qualitatively. Therefore, arms control remains an essential tool to limit the unregulated spread of these systems. Some of these norms may aim at imposing numerical ceilings, while others may prohibit the deployment of the most destabilizing weapons.

The United States and Russia committed in 2021 to resume a Strategic Stability Dialogue (Reif and Bugos 2021). This has led to a new hope in the arms control community that a follow-on treaty to New START may be negotiated. In particular, officials from the Trump administration said that during its last few months, progress had been made in envisaging a more comprehensive bilateral arms control agreement that would cap nonstrategic as well as strategic systems (Pifer 2021). In the United States, such an extension would mostly deal with nuclear gravity bombs, as missile-carried nonstrategic nuclear weapons have already been retired from service. But in Russia, it would concern short-range missiles, such as possibly the SS-26/Iskander missile, SSC-8 (9M729) cruise missile, and sea-based and submarine-launched missiles. Former officials have been very supportive of such an initiative (Gottemoeller 2020). While successful negotiation bringing caps and verification measures on nonstrategic nuclear weapons and their delivery vehicles would be a welcome and useful step, such a positive development remains very ambitious today. These weapons have never been controlled by a verifiable treaty, and creating a framework for some level of verification might be technically possible but require a significant amount of goodwill from the two sides. Given the current context of mistrust and the lack of credibility of both partners to sustain their engagement over the long term, this level of political commitment seems hard to imagine. On the legislative side in the United States, in particular, any deal requiring congressional approval would face a fierce battle (Conley et al. 2021).

Other important objectives, such as extending strategic arms control to other countries, also appear as far out of reach for the foreseeable future. Indeed, all these countries, especially China, have stated that they considered that the gap between the size of their arsenal and those of the United States and Russia was still too large. Without giving up hope that such comprehensive and creative agreements may come to fruition, arms control efforts in the short term can also focus on simpler and more pragmatic endeavors.

First, work is necessary to ensure that current and future strategic arms control agreements encompass all strategic missiles deployed by the two countries. Such an effort can be led within existing structures, or by slightly revising the scope of treaties such as New START.
Concerning that treaty, proposals have been made to capitalize on the Russian decision to count the Avangard as a nuclear warhead mated to an ICBM to make sure that the definitions in a follow-on treaty may specifically include intercontinental ground-launched boost-glide missiles (Acton and Vaddi 2020). Such a move would assure both countries that any hypersonic glide vehicle deployed with a strategic range is accounted for under the treaty, even if it does not rely on a treaty-accounted booster (Tracy 2020c).

Under New START, air-launched missiles are accountable if they are deployed on long-range bombers. To control the number of air-launched cruise missiles, air-launched ballistic missiles, and air-launched boost-glide vehicles deployed, it may be necessary to revise this classification and to count all deployed missiles or restrict their deployment to treaty-accountable heavy bombers (Acton and Vaddi 2020).

Concerning the sea component, submarine-launched nuclear boost-glide missiles could be considered as more classical SLBMs, in the event they were considered as suitable weapons by either of the two countries. US negotiators may feel the need to make sure that long-range nuclear torpedoes are included in the accounted delivery vehicles. This would concern potentially the Russian Poseidon system, which is not in service yet (Acton and Vaddi 2020). Other proposals have been made to scrap this system, as well as nuclear-powered cruise missiles, a design that has been highlighted as especially unsafe (Acton and Vaddi 2020). Currently developed by Russia, the Burevestnik project has reportedly claimed victims among Russian engineers, as an explosion took place in 2019 during the manipulation of a missile previously tested (Macias 2019). But some argued that such a prohibition of this system would be difficult to verify and enforce, and have suggested counting it as strategic air-launched missiles (Arbatov 2019). Convincing Russia to renounce both programs may be preferable in interest of stability, but that would require the United States to announce its readiness to reconsider some of its own projects, opening the door to asymmetric arms control.

Second, it may be useful to restore some controls on intermediate-range missiles, especially in Europe. With the progress made on verification techniques, rebuilding an agreement focusing only on nuclear-tipped missiles has been suggested in Europe. It would, however, entail important monitoring challenges, and would be hard to conceive in Asia given the importance of weapons of these ranges for many countries (Gottemoeller 2020). Proposals have also been made to focus as a first step on intermediate-range ballistic missiles, but as it would not solve the question of the SSC-8 (9M729) cruise missile, developed by Russia despite the prohibition of the INF Treaty, such interim measures are unlikely to receive support from NATO states (Stefanovich 2020). However, the Russian proposal of adopting a moratorium on the deployment of all intermediate range missiles in the European theater in a verified way (TASS 2020) is regarded with some interest in some European capitals. Though not endorsed officially, some countries have expressed their interest in it as a starting point for negotiations (Reif and Bugos 2020). The concrete outlines described by Russian diplomats for reviving the INF regime may indicate that finding a consensus approach may be possible. Dealing with past violations would remain a major hurdle, as well as implementing a deal in the Asian theater, but limited objectives and a step-by-step process may avoid a large-scale deployment of intermediate-range systems, which is in the interest of neither Russia nor NATO (Ryabkov 2021; Gottemoeller 2021). Another
avenue to avoid the political difficulty of reviving the INF Treaty could be to scale down the range of the missiles controlled under New START, and to set the new limitation at above 500 km (Arbatov 2019). The “START” umbrella would therefore be used to cover a new class of weapons. However, this would mean a reconsideration of what “strategic arms control” means.

Adapting New START and reimposing some controls on intermediate-range missiles may appear to be the most classic and prudent way of restarting the arms control discussion between Russia and the United States. However, more creative solutions could also be promoted, if enough political will were gathered on both sides.

This could in particular concern restrictions on the nuclear “exotic systems” mentioned above, anti-missile capabilities or conventional long-range precision strike systems (Williams 2018). The main benefits of such an approach would be that it may appear more attractive to China, as it could lead the United States to limit the deployment of systems that Beijing perceives as a threat by Beijing. In exchange, China could be convinced to accept limitations on some systems without putting in danger the survivability of its nuclear deterrent. With Russia, anti-missile capacities could be traded off against a lower number on nonstrategic nuclear weapons. While asymmetric arms control has the advantage of focusing on the systems of concern for each party involved, it is also difficult to sell politically as it may appear to accept inferiority in one weapon segment or one domain (Maitre 2020b). Flexibility in the ceilings and definitions of systems could be a way to get beyond this difficulty (Williams 2018). Another way to limit political opposition would be to favor CBMs and nonbinding agreements.

Moving Forward on Confidence-building Measures and Risk Reduction Initiatives

If the political environment is not conducive to the adoption of legally binding arrangements, confidence-building measures and risk reduction initiatives may prove useful. The discussion below focuses on several potential approaches.

First, the only multilateral missile-related CBM, the HCoC, addresses the key issue of testing. On that front, subscribing states may attempt to enlarge the scope of the code without reducing its effectiveness. In particular, it could add cruise missiles deployed to deliver nuclear weapons, long-range hypersonic cruise missiles, and long-range hypersonic boost-glide weapons launched from ground, sea, or air (Delory, Maitre, and Masson 2019).

Second, a source of instability derives from the inability to determine whether certain delivery vehicles are being used to carry nuclear warheads or conventional weapons. Based on declaratory policies, states could commit themselves to avoid the deployment of nuclear-tipped and conventional identical missiles at the same location and on the same platform, in particular with regard to hypersonic gliders (Schütz 2019). This kind of proposal, as well as the exchange of more general information on the range, capabilities, and basing mode of hypersonic weapons, may enable potential adversaries to better distinguish between strategic and tactical capabilities, avoid negative arms race spirals and minimize the risk of escalation. It could be usefully complemented by sharing information on doctrines and employment concepts, insofar as it could demonstrate that some capabilities are conceived for specific scenarios and do not aim at threatening an adversary’s ability to retaliate after absorbing a nuclear strike (Wan 2020).
CBMs could also be used as a first step for more ambitious arms control. This could apply to anti-ballistic missile systems with the goal of assuring negotiating partners that such capabilities have no offensive purposes (Brustlein 2018). Unilateral declaration of restraint on nuclear short-range missiles, on the model of the Presidential Nuclear Initiatives, could also be useful to reduce the threat perception of all parties involved.

**Conclusion**

The inability of the three UN panels dealing with missiles to produce a consensus approach on regulating these systems (UNODA n.d.) shows the difficulty of moving constructively on this issue. However, whether it is between major powers or in regional theaters, many tensions and arms race dynamics are based on the unregulated development or deployment of WMD-capable missiles. There is therefore a strong rationale for attempting to revamp existing nonproliferation and arms control agreements on that category of missiles. This need has been emphasized by the UN high representative for disarmament affairs during the second plenary meeting of the Missile Dialogue Initiative (Nakamitsu 2020).

In the short term, more modest steps may be realistically contemplated. They should aim at adapting and strengthening the nonproliferation framework, especially the relevant export control regimes, but also revising bilateral arms control agreements, which are key to limiting the actual numbers of nuclear-capable missiles. Because the current political circumstances make such endeavors difficult, CBMs have an important role to play in limiting the risk of misinterpretation, misunderstanding, and inadvertent use, and they have the ability to involve all current and future missile possessors.

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**Notes on Contributor**

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**References**

Acton, J. 2018. “Hypersonic Weapons Explainer.” Carnegie Endowment for International Peace. https://carnegieendowment.org/2018/04/02/hypersonic-weapons-explainer-pub-75957/

Acton, J., and P. Vaddi. 2020. “A ReSTART for U.S.-Russian Nuclear Arms Control: Enhancing Security through Cooperation.” Paper, Carnegie Endowment for International Peace. https://carnegieendowment.org/2020/10/02/restart-for-u.s.-russian-nuclear-arms-control-enhancing-security-through-cooperation-pub-82705

Arbatov, A. 2019. “A New Era of Arms Control: Myths, Realities and Options.” Carnegie Moscow Center. https://carnegie.ru/commentary/80172
Arms Control Association. 2017. *The Presidential Nuclear Initiatives (Pnis) on Tactical Nuclear Weapons at a Glance*. Fact Sheets & Briefs. [https://www.armscontrol.org/factsheets/pniglance](https://www.armscontrol.org/factsheets/pniglance)

Barrie, D. 2019. “Unstable at Speed: Hypersonics and Arms Control.” *Military Balance Blog*, IISS, October 18. [https://www.iiss.org/blogs/military-balance/2019/10/hypersonics-arms-control](https://www.iiss.org/blogs/military-balance/2019/10/hypersonics-arms-control)

Brockmann, K. 2020. “Controlling Ballistic Missile Proliferation. Assessing Complementarity between the HCoC, MTCR and UNSCR 1540.” *HCoC Research Paper 7*, FRS. [https://www.nonproliferation.eu/hcoc/controlling-ballistic-missile-proliferation-assessing-complementarity-between-the-hcoc-mtcr-and-unsr-1540](https://www.nonproliferation.eu/hcoc/controlling-ballistic-missile-proliferation-assessing-complementarity-between-the-hcoc-mtcr-and-unsr-1540)

Brockmann, K., and S. Bauer. 2017. “3D Printing and Missile Technology Controls.” *SIPRI Background Paper*. [https://www.sipri.org/publications/2017/sipri-background-papers/3d-printing-and-missile-technology-controls](https://www.sipri.org/publications/2017/sipri-background-papers/3d-printing-and-missile-technology-controls)

Brustlein, C. 2018. “The Erosion of Strategic Stability and the Future of Arms Control.” *Proliferation Papers*, n°60, IFRI. [https://www.ifri.org/en/publications/etudes-de-lifri/proliferation-papers/erosion-strategic-stability-and-future-arms](https://www.ifri.org/en/publications/etudes-de-lifri/proliferation-papers/erosion-strategic-stability-and-future-arms)

 Bulletin of the Atomic Scientists. 2015. “Test Ban for Hypersonic Missiles?, Roundtable with Tong Zhao, Rajaram Nagappa and Mark Gubrud.” [https://thebulletin.org/roundtable/test-ban-for-hypersonic-missiles](https://thebulletin.org/roundtable/test-ban-for-hypersonic-missiles)

Champlin, L. 2009. “China, Russia Agree on Launch Notification.” *Arms Control Today*, [https://www.armscontrol.org/act/2009-11/china-russia-agree-launch-notification](https://www.armscontrol.org/act/2009-11/china-russia-agree-launch-notification)

Congressional Research Service. 2020. “Conventional Prompt Global Strike and Long-Range Ballistic Missiles: Background and Issues.” R41464. [https://sgp.fas.org/crs/nuke/R41464.pdf](https://sgp.fas.org/crs/nuke/R41464.pdf)

Conley, H., et al. 2021. “The Future of U.S.-Russian Arms Control: Principles of Engagement and New Approaches.” *Report*, CSIS. [https://www.csis.org/analysis/future-us-russian-arms-control-principles-engagement-and-new-approaches](https://www.csis.org/analysis/future-us-russian-arms-control-principles-engagement-and-new-approaches)

Cordesman, A. 2021. “The Other Sides of Renegotiating the JCPOA Iran Nuclear Agreement.” *Commentary*, CSIS, April 15. [https://www.csis.org/analysis/other-sides-renegotiating-jcpoa-iran-nuclear-agreement](https://www.csis.org/analysis/other-sides-renegotiating-jcpoa-iran-nuclear-agreement)

David, S. 2020. “Hypersonic Weapons – A Technological Challenge for Allied Nations and NATO?.” Final Report, Science and Technology Committee, NATO Parliamentary Assembly. [https://www.nato-pa.int/download-file?filename=sites/default/files/2020-07/039%20STC%202020%20EU%20HYPERSONIC%20WEAPONS.pdf](https://www.nato-pa.int/download-file?filename=sites/default/files/2020-07/039%20STC%202020%20EU%20HYPERSONIC%20WEAPONS.pdf)

Delory, S. 2011. “Missile Non-proliferation: An Alternative Approach.” *Research & Documents*, n°2/2011, FRS, [in French]. [https://www.nonproliferation.eu/hcoc/non-proliferation-des-missiles-une-approche-alternative](https://www.nonproliferation.eu/hcoc/non-proliferation-des-missiles-une-approche-alternative)

Delory, S. 2015. “Le missile balistique avion stratégique du pauvre.” *Penser les Ailes Françaises*. 33, [in French]. [https://www.nonproliferation.eu/hcoc/le-missile-balistique-aviation-strategique-du-pauvre](https://www.nonproliferation.eu/hcoc/le-missile-balistique-aviation-strategique-du-pauvre)

Delory, S. 2017. “Le développement des technologies balistiques hors du MTCR: Conséquences pour le régime.” *Recherches & Documents*, n°06/2017, FRS, [in French]. [https://www.frstrategie.org/publications/recherches-et-documents/developpement-technologies-balistiques-hors-mtcr-consequences-pour-regime-2017](https://www.frstrategie.org/publications/recherches-et-documents/developpement-technologies-balistiques-hors-mtcr-consequences-pour-regime-2017)

Delory, S. 2019. “Missile Technology and Challenges Arising from Its Proliferation.” Conference Reader, Capturing Technology. Rethinking Arms Control. Berlin. [https://rethin kingarmscontrol.de/wp-content/uploads/2020/10/20-AA-RAC-Reader-2020-10-28-final-korr-kompr.pdf](https://rethin kingarmscontrol.de/wp-content/uploads/2020/10/20-AA-RAC-Reader-2020-10-28-final-korr-kompr.pdf)

Delory, S. 2020. “Ballistic Missiles and Conventional Strike Weapons: Adapting the HCoC to Address the Dissemination of Conventional Ballistic Missiles.” *HCoC Research Paper 6*, FRS. [https://www.nonproliferation.eu/hcoc/ballistic-missiles-and-conventional-strike-weapons-adapting-the-hcoc-to-address-the-dissemination-of-conventional-ballistic-missiles](https://www.nonproliferation.eu/hcoc/ballistic-missiles-and-conventional-strike-weapons-adapting-the-hcoc-to-address-the-dissemination-of-conventional-ballistic-missiles)

Delory, S., E. Maitre, and J. Masson. 2019. “Opening HCoC to Cruise Missiles: A Proposal to Overcome Political Hurdles.” *HCoC Research Paper 5*, FRS. [https://www.nonproliferation.eu/hcoc/opening-hcoc-to-cruise-missiles-a-proposal-to-overcome-political-hurdles](https://www.nonproliferation.eu/hcoc/opening-hcoc-to-cruise-missiles-a-proposal-to-overcome-political-hurdles)

Federation of American Scientists. 1998. “UNSCOM and Iraqi Missiles”. [https://fas.org/nuke/guide/iraq/missile/unscom.htm](https://fas.org/nuke/guide/iraq/missile/unscom.htm)
FRS. 2021. “Confidence-building Measures and New Missile Technologies”. Webinar on the margins of the HCoC Annual Regular Meeting, FRS. July 6. https://www.nonproliferation.eu/hcoc/webinar-confidence-building-measures-and-new-missile-technologies/
Gaillard-Sborowsky, F., I. Sourbes-Verger, and J. J. Tortora. 2018. PSPL: Petits Satellites – Petits lanceurs, FRS. [in French] https://www.geostrategia.fr/documents/rapport-final-etude-pspl-petits-satellites-petits-lanceurs/
Global Times. 2020. “China, Russia Extend Missile Launch Notification Agreement to Maintain Global Strategic Stability.” December 15. https://www.globaltimes.cn/content/1210062.shtml
Gottemoeller, R. 2019. "Speech at the Swedish Institute for International Affairs”. September 10. https://www.nato.int/cps/en/natohq/opinions_168662.htm
Gottemoeller, R. 2020. "Rethinking Nuclear Arms Control.” The Washington Quarterly 43 (3): 139–159. doi:10.1080/0163660X.2020.1813382.
Gottemoeller, R. (@Gottemoeller). 2021. “I Was Pleasantly Surprised by This Pragmatic Approach Outlined by DFM Ryabkov – Here’s Hoping that the United States and Russia Can Work Out a Compromise in the Coming Strat-stability Talks.” Twitter, 14 July 2021. https://twitter.com/Gottemoeller/status/1415425820403793923
Hanham, M., and Xu, T. 2021. “The Next 50 Years of Missile Proliferation,” in The Next Fifty Years of Nuclear Proliferation. Sharon Squassoni, ed. The Next Fifty Years of Nuclear Proliferation. Sharon Squassoni. George Washington University. February 15. https://oneearthfuture.org/program/open-nuclear-network/publications/essay-next-50-years-missile-proliferation
Héau, L., and E. Maitre. 2020. The HCoC: A Small yet Key Tool against Ballistic Missile Proliferation. FRS. HCoC Issue Brief. https://www.nonproliferation.eu/hcoc/the-hcoc-small-yet-key-tool-against-ballistic-missile-proliferation/ Hoffmann, F. 2021. “Strategic Non-nuclear Weapons and Strategic Stability – Promoting Trust through Technical Understanding,” The NPT and the P5 Process, FRS. https://www.frstrategie.org/en/programs/npt-and-the-p5-process/strategic-non-nuclear-weapons-and-strategic-stability-promoting-trust-through-technical-understanding-2021
Idiart, A. 2017. “The Role of Intangible Transfer of Technology in the Area of Ballistic Missiles – Reinforcing the Hague Code of Conduct and the MTCR.” HCoC Research Paper, FRS. https://www.nonproliferation.eu/hcoc/the-role-of-intangible-transfer-of-technology-in-the-area-of-ballistic-missiles-reinforcing-the-hague-code-of-conduct-and-the-mtcr/
Karnozov, V. 2019. “Putin Reveals Zircon Mach 9 Missile Specification.” Aviation International News, 22 February. https://www.ainonline.com/aviation-news/defense/2019-02-22/putin-reveals-zircon-mach-9-missile-specification/
Kasapoğlu, C., and S. Özkaraşahin. 2021. “In The Shadow Of A Missile: Assessing The Armenian Military’s SS-26 Iskander Debeacle.” Defense Intelligence Sentinel, EDAM. https://edam.org.tr/en/iskanderdebeacle/
Lavars, N. 2018. “A Booster A Week? Rocket Lab Moves Towards Mass Production with “Huge” New Facility.” New Atlas, October 17. https://newatlas.com/rocket-lab-mass-production-facility/56820/
Lele, A. 2017. “Hypersonic Weapons.” ISDA Occasional Paper No. 46, Institute for Defense Studies & Analyses. https://idsa.in/occasionalpapers/op_46_hypersonic_weapons
Lumpe, L. 1993. “Zero Ballistic Missiles and the Third World.” Arms Control 14 (1): 208–229. doi:10.1080/01440389308404023.
Macias, A. 2019. “US Intel Report Says Mysterious Russian Explosion Was Triggered by Recovery Mission of Nuclear-Powered Missile, Not a Test.” CNBC, September 11. https://www.cnbc.com/2019/08/29/intel-says-russian-explosion-was-not-from-nuclear-powered-missile-test.html
Maitre, E. 2020a. The Challenges of Nuclear Disarmament Verification. FRS. Research & Documents. https://www.frstrategie.org/en/publications/recherches-et-documents/challenges-nuclear-disarmament-verification-2020/
Maitre, E. 2020b. “What Prospects for Arms and Missile Control after the End of the INF Treaty?” In Recherches & Documents N°03/2020. FRS. https://frstrategie.org/en/publications/recherches-et-documents/what-prospects-arms-and-missile-control-after-end-inf-treaty-2020

Maitre, E., and S. Moreau-Brillaltz. 2022. “The Hague Code of Conduct: Encouraging the Peaceful Use of Outer Space and Curbing Ballistic Missile Proliferation.” HCoC Research Paper 9, FRS.

Masson, J. 2018. Les missiles des Houthis: Proliferation balistique et groupes armés non-étatiques. FRS, Research & Documents n°11/2018. [in French]. https://www.frstrategie.org/publications/recherches-et-documents/missiles-houthis-proliferation-balistique-groupes-armes-non-etatiques-2018

McCartier, J. 2017. “DON Innovator Embraces a New Disruptive Technology: Blockchain.” US Department of the Navy. www.seacnav.navy.mil%2Finnovation%2FDocuments%2F2017%2F06%2FBlockchain.pdf?usp=AOvVav1-NbHhqS2iEl4W4tbWzHd/

Missile Defense Project. 2016. “‘Hatf 9 Nasr’ Missile Threat, Center for Strategic and International Studies”. Last modified 15 June 2018. https://missilethreat.csis.org/missile/hatf-9/

Missile Defense Project. 2020. “‘DF-17’ Missile Threat, Center for Strategic and International Studies.” Last modified 2 August 2021. https://missilethreat.csis.org/missile/df-17/

Mistry, D. 2003. Containing Missile Proliferation: Strategic Regimes, Security Regimes, and International Cooperation in Arms Control. University of Washington Press.

MTCR. 2019. “Item 19, Category II, Equipment, Software And Technology Annex.” updated on 11 October 2019. https://mtcr.info/wordpress/wp-content/uploads/2019/10/MTCR-TEM_Technical_Annex_2019-10-11-1.pdf

Nakamitsu, I. 2020. “Keynote Address. Second Meeting (Online) of the Missile Dialogue Initiative (MDI).” 7 September 2020. https://www.iiss.org/research/defence-and-military-analysis/missile-dialogue-initiative

Nnsa, N. E. W. S. 2009. “NNSA Announces Equivalent of More than 15,000 Nuclear Weapons of Russian HEU Eliminated.” September 23. https://geneva.usmission.gov/2009/09/23/nuclear-weapons/

NTI. 2004. “India, Pakistan Agree on Missile Test Notification.” https://www.nti.org/tni/article/india-pakistan-agree-on-missile-test-notification

Ozga, D. 1994. “A Chronology of the Missile Technology Control Regime.” The Nonproliferation Review 1 (2): 66–93. doi:10.1080/10736709408436541.

Pasandideh, S. 2019. “The End of the “INF Treaty” and the US-China Military Balance.” The Nonproliferation Review 26 (3–4): 267–287. doi:10.1080/10736700.2019.1646466.

Pasco, X., and S. Delory. 2017. “Light Launchers and Microsatellites: Towards a Risk of Ballistic Proliferation under the Guide of Spatial Development.” HCoC Research Papers, FRS. https://www.nonproliferation.eu/hcoc/wp-hcoc/uploads/2017/02/Light-launchers-and-microsatellites.pdf/

Pifer, S. 2021. The Art of Negotiating Non-Strategic Nuclear Weapons. Freeman Spogli Institute for International Studies. Commentary. https://fsi.stanford.edu/news/art-negotiating-non-strategic-nuclear-weapons/

Raytheon News. 2015. “To Print a Missile: Raytheon Research Points to 3-D Printing for Tomorrow’s Technology.” March 19. https://www.raytheon.com/news/feature/print-missile/

Recognition, N. 2018. “Video: First Operational Use of MdCN Naval Cruise Missile by French Navy FREMM Frigates,” Navy Recognition, April 2018. http://www.navyrecognition.com/index.php/news/defence-news/2018/pril-2018-navy-naval-defense-news/6137-video-first-operational-use-of-mdcn-naval-cruise-missile-by-french-navy-fremm-frigates.html

Reif, K. 2020. “U.S. Continues Intermediate-Range Missile Pursuit.” Arms Control Today. https://www.armscontrol.org/act/2020-06/news/us-continues-intermediate-range-missile-pursuit

Reif, K., and S. Bugos. 2020. “France Seeks Dialogue on Post-INF Treaty Arms Control.” Arms Control Today. https://www.armscontrol.org/act/2020-01/news-briefs/france-seeks-dialogue-post-inf-treaty-arms-control/
Reif, K., and S. Bugos. 2021. “U.S., Russia Agree to Strategic Stability Dialogue.” Arms Control Today. https://www.armscontrol.org/act/2021-07/news/us-russia-agree-strategic-stability-dialogue/

Rempfer, K., and J. Gould. 2020. “US Army Completes Third Test of Lockheed’s Precision Strike Missile.” Defense News, April 30. https://www.defensenews.com/news/your-army/2020/04/30/us-army-completes-third-test-of-lockheeds-precision-strike-missile/

Roblin, S. 2021. “Russia Shows off Footage of Iskander Missile Hitting A Hospital in Highlight Reel Meant to Defend the Weapon’s Effectiveness.” Forbes, March 1. https://www.forbes.com/sites/sebastienroblin/2021/03/01/moscow-assures-world-its-iskander-missile-can-precisely-hit-a-hospital/?sh=77bf19987c5

Ryabkov, S. 2021. "Keynote Address." 2021 Carnegie International Nuclear Policy Conference, https://carnegieendowment.org/2021/06/24/2021-carnegie-international-nuclear-policy-conference/KB0Q

Schütz, T. 2019. “Hypersonic Weapon Systems Will Decrease Global Strategic Stability – And Current Control Regimes Won’t Do.” DGAP Kompakt, https://dgap.org/en/research/publications/technology-and-strategy

Shaw, R. 2017. “3D Printing: Bringing Missile Production to a Neighborhood near You.” NTI, https://www.nti.org/analysis/articles/3dprinting-bringing-missile-production-neighborhood-near-you/ 

Siddhartha, V. 2017. “Spaceplanes, Hypersonic Platforms and the Missile Technology Control Regime.” In Strategic and Security Studies Programme. National Institute of Advanced Studies. http://isssp.in/spaceplanes-hypersonic-platforms-and-the-missile-technology-control-regime/

Speier, R., G. Nacouzi, C. Lee, and R. Moore. 2017. “Hypersonic Missile Nonproliferation. Hindering the Spread of a New Class of Weapons.” Santa Monica, CA: RAND Corporation. https://www.rand.org/pubs/research_reports/RR2137.html/

Stefanovich, D. 2020. How to Address the Russian post-INF Initiatives. European Leadership Network. Commentary. https://www.europeanleadershipnetwork.org/commentary/how-to-address-the-russian-post-inf-initiatives/

Stimson. 2005. “Agreement between India and Pakistan on Pre-Notification of Flight Testing of Ballistic Missiles.” https://www.stimson.org/2012/agreement-between-india-and-pakistan-on-pre-notification-of-flight-tes/

TASS. 2020. “Moscow Ready Not to Deploy 9M729 Missiles in European Russia, Putin Says.” October 26. https://tass.com/politics/1216411

Terra trespass, B., and E. Maitre. 2020. 50th Anniversary of the NPT: Evolutions and Prospects. FRS. Research & Documents. https://www.frstrategie.org/en/publications/recherches-et-documents/50th-anniversary-npt-evolutions-and-prospects-2020

Tracy, C. 2020a. Setting the Record Straight on Hypersonic Weapons. Union of Concerned Scientists. All Things Nuclear. https://allthingsnuclear.org/ctracy/setting-the-record-straight-on-hypersonic-weapons/

Tracy, C. 2020b. The Latest US Test Flight of a Hypersonic Weapon: The Common Hypersonic Glide Body. Union of Concerned Scientists. All Things Nuclear. https://allthingsnuclear.org/ctracy/the-latest-us-test-flight-of-a-hypersonic-weapon-the-common-hypersonic-glide-body/

Tracy, C. 2020c. Fitting Hypersonic Weapons into the Nuclear Arms Control Regime. Union of Concerned Scientists. All Things Nuclear. https://allthingsnuclear.org/ctracy/fitting-hypersonic-weapons-into-the-nuclear-arms-control-regime/

Trevithik, J. 2019. “U.S. Inspectors Have Examined Russia’s Imminently Operational Hypersonic Missile.” The Drive. November 26. https://www.thedrive.com/the-war-zone/31215/u-s-inspectors-have-examined-russia-s-imminently-operational-hypersonic-missile

Trezza, C. 2013. “Controlling Proliferation of WMD Delivery Means: Necessary Next Steps.” Commentary, European Leadership Network. July 8. https://www.europeanleadershipnetwork.org/commentary/controlling-proliferation-of-wmd-delivery-means-necessary-next-steps/
