THE SHIELD AND THE SWORD:

THE IMPACT OF BALLISTIC MISSILE DEFENCE ON MISSILE PROLIFERATION

HCOC RESEARCH PAPERS **N°15** - DECEMBER 2025

In Israel and in Ukraine, major ballistic missile attacks have led to the large-scale use of missile defence, demonstrating its strengths and limitations in protecting military assets and populations from the effects of missile strikes.

This massive use of missile strikes on the ground, on the one hand, and the deterioration of strategic relations between major powers, on the other, are leading to a renewed interest in the acquisition of missile defence. The Trump administration has very visibly expressed this interest with the launch of the 'Golden Dome' programme. These investments are largely justified by the dissemination of missile technologies worldwide. Some of their promoters have asserted that they may bring stability or even contribute to curbing missile proliferation, as countries may refrain from developing weapons perceived as too vulnerable to defence. However, the spread and increased capacity of missile defence is also playing a role in missile proliferation. Indeed, countries operating missile forces are incentivised to increase their arsenals in the hopes of overcoming defensive architectures. Missiles are also becoming more sophisticated to avoid interception. Finally, the development of missile defence is leading to a negative spiral regarding the militarisation of space.

Arms control may be used to mitigate these dynamics, but it faces many challenges. Non-proliferation tools can be useful but limited, as many of the countries fielding missiles today are also involved in producing them. Confidence-building measures may play a role in restricting destabilising behaviours in space and limiting misunderstandings linked to the deployment of missile defence assets.

Authors: Stéphane Delory & Emmanuelle Maitre

DISCLAIMER

This document was produced with the financial assistance of the European Union. The contents of this document are the sole responsibility of the Fondation pour la Recherche Stratégique and can under no circumstances be regarded as reflecting the position of the European Union.

ACKNOWLEDGEMENT

Edited by Cadenza Academic Translations

CONTENTS

ABBREVIATIONS

ABM (Treaty): Anti-Ballistic Missile Treaty

ASAT: Anti-satellite

C2: Command and control

CBM: Confidence-building measure

CD: Conference on Disarmament

DPRK: Democratic People's Republic of Korea

EPAA: European Phased Adaptive Approach

ESSI: European Sky Shield Initiative

FOBS: Fractional Orbital Bombardment System

GBI: Ground-Based Interceptor

GGE: Group of Governmental Experts

GMD: Ground-Based Midcourse Defense

GPALS: Global Protection against Limited Strikes

HCoC: Hague Code of Conduct against Ballistic Missile Proliferation

ICBM: Intercontinental ballistic missile

IRBM: Intermediate-range ballistic missile

ISR: Intelligence, surveillance, and reconnaissance

MAD: Mutual assured destruction

MARV: Manoeuvrable re-entry vehicle

MIRV: Multiple independently targetable re-entry vehicle

MRBM: Medium-range ballistic missile

MRV: Multiple re-entry vehicle

MTCR: Missile Technology Control Regime

NGI: Next Generation Interceptor

PPWT: Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects

PWSA: Proliferated Warfighter Space Architecture

ROK: Republic of Korea

SALT: Strategic Arms Limitation Talks

SDI: Strategic Defense Initiative

SRBM: Short-range ballistic missile

THAAD: Terminal High Altitude Area Defense

UAE: United Arab Emirates

UAV: Unmanned aerial vehicle

UNGA: United Nations General Assembly

USSR: Union of Soviet Socialist Republics

WMD: Weapon of mass destruction

INTRODUCTION

The emergence of nuclear intermediate-range (IRBM) and then intercontinental ballistic missile (ICBM) programmes in the 1950s very quickly led Soviet and American engineers to consider developing anti-missile systems.

As early as 1953, the development of an anti-ballistic capability was identified as a national priority by the Central Committee of the Communist Party of the Soviet Union. Progress was fairly rapid and led, in 1961, to the first successful interception of a medium-range ballistic missile (MRBM) by the experimental V-1000 interceptor. In the United States, programmes such as the Nike Zeus led to around a dozen tests in 1962–1963 but were eventually largely curbed by the Johnson administration. At the time, missile defence's drawbacks were seen as trumping its benefits: though interception with conventional explosives was in theory possible, technical constraints implied the use of nuclear devices. Even in this case, territorial defence remained ineffective without the development of a massive and costly architecture of radars and the multiplication of launch sites across the country, raising the costs to such levels that point defence of strategic infrastructures was rapidly preferred, in the United States as well as the Soviet Union.

Therefore, freezing the offensive arsenal and tightly restricting missile defence via legally binding agreements appeared as the most effective solutions. In the Soviet Union, whose defence budget was already overburdened by massive investments in order to catch up with the United States' offensive component, the conclusion was more or less the same. The decision was made to deploy a rudimentary defence around Moscow, but the leadership realised that expanding it would be economically unfeasible. In the framework of the first agreement on arms control (SALT I), Washington and Moscow agreed on limiting missile defence through the 1972 Anti-Ballistic Missile (ABM) Treaty.

However, the appeal of protecting the population, and not just avenging it through second strike, led to new projects, most famously Ronald Reagan's Strategic Defense Initiative (SDI), a project that seemed to lose its relevance with the end of the Cold War but which remained influential in US thinking.

With the first Gulf War, the SDI, scaled down and re-baptised Global Protection against Limited Strikes (GPALS), appeared as the ultimate solution against emerging intercontinental missile threats. Despite the reluctance of the Clinton administration, the proliferation of weapons of mass destruction (WMDs) and their means of delivery led to new concerns. It convinced the George W. Bush administration to withdraw from the ABM Treaty and propose renewed ambitions for different layers of missile sensors and interceptors. The 'Golden Dome' project announced by Donald Trump on 27 January 2025 follows this heritage, but it also encompasses the recent experience of massive operational use of defences in conflicts. Since 2022, Russia has engaged significantly in missile strikes in its war against Ukraine, and acquiring and operating adequate missile defence systems has been a key concern in Kyiv. In April 2024, October 2024, and June 2025, Iran launched waves of missile strikes against Israel in the context of their bilateral conflict. The long-standing and expanded Israeli investments in missile defence have proved effective in protecting the territory against such attacks.

These precedents have fuelled an interest in missile defence, symbolised by Golden Dome, but not limited to the United States or strategic missile defence. More than 30 countries currently hold missile defence assets, the majority of which can be considered an extension of air defence aimed at tactical threats. Many other countries have displayed their interest in acquiring systems in the future, in particular in Europe through the European Sky Shield Initiative (ESSI) launched by Germany.[1]

Missile defence has been criticised for having a potential negative impact on strategic stability and fuelling an arms race. As it is primarily developed in order to respond to the spread of missiles worldwide, it is essential to understand how defensive capacities affect proliferation dynamics.

Depending on the expectations one may have regarding the performance of missile defence, the immediate conclusions may differ. Thus, if one is fully confident that interception can be successful in almost all cases, this may be seen as decreasing the incentive to develop missiles as a category of weapons, as they become largely ineffective. However, if one believes that, through number or sophistication, it is possible to defeat defensive systems, this may be seen as fuelling a trend whereby actors expand their missile forces and increase their penetrability.

[1] *'10 NATO Allies take further step to boost European air and missile defence capabilities,' NATO, 11 October 2023, https://www.nato.int/cps/fr/natohq/news_219119.htm?selectedLocale=en*

This paper explores the interactions between missile defence and offensive missile proliferation, focusing first of all on the way in which the spread of missiles has justified the development and acquisition of missile defence in order to preserve strategic stability, to respond to WMD proliferation, or for use in combat. It studies the various dynamics observed following the deployment of defensive architectures, in terms of arms racing, the modernisation and diversification of arsenals, and the militarisation of space.

Finally, it concludes on the ways in which arms control, non-proliferation, and confidence-building measures could address and mitigate these phenomena despite numerous challenges.

MISSILE DEFENCE: FROM ESCAPING 'MAD' TO DEFENDING CITIES

MISSILE DEFENCE AS A STRATEGIC ASSET

The ambiguous relationship between missile defence and strategic stability

During the Cold War, the notion of strategic stability emerged between the United States and the Soviet Union as an equilibrium situation in which neither adversary had an incentive to conduct a first nuclear strike. As Albert Wohlstetter and Thomas Schelling theorised in their writings, this notion was built on the ability to respond to any first strike with a nuclear reprisal of such force that the enemy's demographic and economic potential would be destroyed. Known as mutual assured destruction (MAD), this concept was rapidly conceived as a minimal capability, ensuring that any enemy would be deterred from launching a massive strike. In the 1960s in particular, Washington and Moscow actively sought to guarantee MAD by diversifying their means of delivery or increasing their numbers. At the time, strategic ballistic missile defence emerged as a possible asset, which would increase the resilience of arsenals by reducing their vulnerability to a first strike. Missile defence was thus perceived as a way to bypass MAD and restore nuclear options by neutralising the second-strike capability of an adversary.

During this initial phase, missile defence was perceived as sustainable. However, rapid technological progress accompanying the development of ballistic systems and the ever-increasing number of vehicles to be intercepted made it necessary to consider strategic ballistic defence from a limited perspective. Even in a limited context, defined as the defence of a small number of strategic infrastructures (ICBM fields, command and control [C2] infrastructure), its effectiveness was called into question by the rapid increase of offensive systems and the introduction of multiple re-entry vehicle (MRV) and multiple independently targetable re-entry vehicle (MIRV) technologies. From the mid-1960s onwards, it became apparent that while defences could help limit the effects of a limited strike or ensure the survival of a minimum number of offensive systems, their deployment would encourage the adversary to multiply its strike capabilities, fuelling the arms race. Strategic defences were therefore quickly regarded as factors of instability.

Strategists in the 1960s drew contrasting conclusions from initial practical work as well as theoretical analysis on missile defence. Missile defence might contribute to stability if used in a limited fashion to protect strategic infrastructure and therefore increase the credibility of a MAD posture. But given the ability of an adversary to increase its offensive arsenal, and the cost of the failure of defensive architecture, using ballistic missile defence as a shield to protect oneself from a nuclear strike was financially out of reach and would lead to an arms race, since the adversary would always be tempted to overcome such defences.

The Anti-Ballistic Missile (ABM) Treaty, signed jointly with the Strategic Arms Limitation Treaty (SALT) I (1972), reflected this ambivalence. By limiting the number of systems that could be deployed and the number of sites that could be protected, the Treaty simultaneously recognised the contribution of anti-ballistic defence to strengthening second-strike capability, but also its destabilising nature in the absence of limitations on the number of interceptors.

It is interesting to note that on the Soviet side in particular, given the significant technological advances and investments already made to build a system capable of protecting Moscow, the main challenge was to preserve these gains and hinder the systematic development of new defences, in order to avoid an offensive and defensive arms race that the USSR knew it could not win. The approach was therefore not focused on the notion of instability in the strategic relationship, but primarily aimed at preventing an arms race without impeding the defence of Moscow.

A point of contention in strategic relations

Yet, over time, US ambitions in the field of defence, and the inability of the Soviet Union to follow and replicate these investments, modified the Soviet Union's understanding and led it to argue that restricting missile defence was essential to preserving strategic stability.

The first moment of tension appeared with the Strategic Defense Initiative (SDI) announced by the Reagan administration. In a famous speech of March 1983, Ronald Reagan called on the US scientific community to make nuclear weapons '*impotent and* *obsolete'* through missile defence. The Republican president shared a vision with the '*ultimate goal of eliminating the threat posed by strategic nuclear missiles*', which would lead to '*eliminat[ing] the weapons themselves*', to 'reduce the danger of nuclear war' in the interest of '*mankind and world peace*'.[2] The US administration justified the need to invest in defence based on humanitarian concerns ('*Wouldn't it be better to save lives than to avenge them?*') and an imbalance in the strategic relationship with Moscow in favour of the USSR. It put forward the moral necessity to try and protect the population against the nuclear risk, but also to strengthen deterrence by removing any first-strike incentive.[3] The Reagan administration proposed the concept of 'cooperative transition', suggesting that the Soviet Union could benefit from establishing its own defences in order to build less confrontational relations between the two countries.[4] Yet, the Kremlin was unconvinced. Immediately after Reagan's speech, General Secretary Andropov accused '*the United States of attempting to undermine the existing strategic balance by seeking to deny Soviet strategic forces the ability to retaliate effectively to a U.S. first strike*'.[5]

The project was revised several times and adapted to new threats in 1991. Its derivative, GPALS, relied on ground and space interceptors and was defined as a capability to intercept limited strikes, coming from proliferating states but also from hypothetical rogue entities emerging from the former USSR. GPALS was designed to intercept the full load of a submarine-launched ballistic missile (SLBM) or of an ICBM regiment, equating to the interception of a limited strategic strike from Russia or China. Downplayed by Democratic lawmakers, who were more concerned about the potential instability caused by strategic defence and unwilling to follow plans that would lead to the militarisation of space, the SDI and GPALS nonetheless paved the way for the development of kinetic ground-based interceptors that constitute part of current US defence, but also for that of certain elements of existing US space architectures.

The political demise of the SDI and GPALS in the 1990s seemed to indicate that the universalisation of the concept of strategic stability based on offensive deterrence, arms control, and shared vulnerability had been established and remained dominant in relations between the major nuclear powers. For instance, the United Nations General Assembly (UNGA) adopted on 1 December 1999 a resolution that called the ABM Treaty '*a cornerstone for maintaining global peace and security and strategic stability*'.[6] During the negotiation of the START II Treaty, Moscow conditioned its ratification on the reaffirmation of the protocols of the ABM Treaty, and missile defence developments in the United States, among other factors, actually led to deferred ratification by the Duma.[7]

Yet, the return of a Republican administration to the White House in 2000 was followed by ambitious announcements regarding the implementation of the National Missile Defense strategy. The Bush Nuclear Posture Review included active and passive defence as one of the three components of the 'New Triad', alongside nuclear and non-nuclear strategic strike systems and a revitalised defence industry. One of the avowed goals of the administration was to use this combination of capabilities to limit the role of nuclear weapons in its defence strategy.[8]

Unwilling to be constrained by what it perceived as old-fashioned and obsolete agreements, the United States decided to withdraw from the ABM Treaty on 14 June 2002. Over the years, Republican lawmakers and experts supported homeland missile defence as a way of strengthening deterrence: it would in particular make extended deterrence more credible by limiting the potential risks taken by the United States in support of its allies. It would also give Washington more leverage in a crisis by reducing the potential cost of a nuclear retaliation.

On the opposite side of the aisle, voices warned about the risk of an arms race and of instability, as well as denouncing the high costs of such projects

[2] *Ronald Reagan, 'Address to the Nation on Defense and National Security', Ronald Reagan Presidential Library & Museum, 23 March 1983,* https://www.reaganlibrary.gov/archives/speech/address-nation-defense-and-national-security
[3] *Keith B. Payne,* Missile Defense in the 21st Century: Protection Against Limited Threats, *Westview Press, 1991.*
[4] *Paul H. Nitze, 'On the Road to a More Stable Peace', University of Minnesota, 20 February 1985,* https://dp.la/item/074cf1015eba28c96cfb4164b99acd69
[5] *Pavel Podvig, 'Did Star Wars Help End the Cold War? Soviet Response to the SDI Program',* Science & Global Security, *vol. 25, no. 1, 2017, pp. 3–27,* https://scienceandglobalsecurity.org/archive/sgs25podvig.pdf
[6] *Resolutions Adopted by the General Assembly [on the report of the First Committee (A/54/563)], 54/54. General and complete disarmament, A: Preservation of and Compliance with the Treaty on the Limitation of Anti-Ballistic Missile Systems, A/RES/54/54, 10 January 2000,* https://digitallibrary.un.org/record/400982?ln=en&v=pdf
[7] *Russia eventually ratified START II in 2000 but withdrew from the Treaty following the US withdrawal from the ABM Treaty in 2002.*
Alexander A. Pikayev, 'The Rise and Fall of START II: The Russian View', Non-Proliferation Project, Global Policy Program, *September 1999,* https://ciaotest.cc.columbia.edu/wps/pia01/index.html#c
[8] *Excerpts of Nuclear Posture Review, Submitted to Congress on 31 December 2001,* https://uploads.fas.org/media/Excerpts-of-Classified-Nuclear-Posture-Review.pdf

and doubting their actual effectiveness in protecting against all ballistic attacks.[9]

Russian and Chinese opposition

Abroad, the Bush administration's homeland missile defence policy was progressively criticised. In 2001, Vladimir Putin regretted the decision but deemed '*with full confidence that the decision made by the President of the United States does not pose a threat to the national security of the Russian Federation*'.[10] But the signature of the SORT treaty in 2002 seemed to support the idea of a common acceptation of missile defence by Russia. However, a few years later, and especially after the souring of US–Russian relations, linking the 2002 withdrawal to a deterioration of international stability was a regular feature of Russian speeches and communications.

In 2009, the Russian president predicted that with national missile defence deployed in the United States, '*the balance will be disrupted and they [Americans] will do whatever they want, and aggressiveness will immediately arise both in real politics and economics*.'[11] During the New START treaty negotiations, the Obama administration refused to scale down US missile defence but instead devoted considerable diplomatic efforts to convincing Moscow that it was only designed against proliferating states. In some ways, the ratification of New START confirmed that missile defence was now a part of the strategic balance, even if Vladimir Putin, in 2018, still described the ABM Treaty as the '*cornerstone of the international security system*', an agreement that 'prevented either party *from recklessly using nuclear weapons*'.[12]

In parallel, Russian diplomats have gradually stressed the necessity of linking defensive and offensive systems in any attempt to create new arms control instruments. Thus, Sergey Ryabkov evoked in 2021 the 'strategic equation' that included defensive capacities as well as nuclear and non-nuclear strategic systems: '*We do not intend to give up the principle of an inseparable link between strategic offensive and strategic defensive arms, which is fixed in the valid New Start Treaty. This is why a proper account of the ABM variable has no alternative for us*.'[13]

Interestingly, most Russian experts, backed by their leaders' statements, seem to agree that in the short term, US missile defence assets do not actually pose a threat to Russian reprisal capacity. However, there is a perceived need to anticipate future developments that could prove to be a challenge for Russian deterrence.[14]

As strategic stability is no longer a strictly bilateral issue, it is not surprising that similar concerns are expressed in China. Since the 2000s, Chinese officials complained that the United States, through the missile defence programme, is trying to achieve unilateral strategic superiority by strengthening American security at the expense of the security of others.[15] Ten years later, Xi Jinping noted, in a joint statement with his Russian counterpart, that '*the development of US strategic missile defence systems [...] continue[s] to have a serious negative impact on international and regional strategic balance, security, and stability*.'[16]

Golden Dome: A new ambition

On 27 January 2025, the White House issued a presidential executive order entitled 'The Iron Dome

[9] *Leah Matchett, 'Debating Missile Defense: Tracking the Congressional Record',* Arms Control Today, *March 2021,* *https://www.armscontrol.org/act/2021-03/features/debating-missile-defense-tracking-congressional-record*

[10] *'A Statement Regarding the Decision of the Administration of the United States to Withdraw from the Antiballistic Missile Treaty of 1972', Kremlin.ru, 13 December 2001,* *http://en.kremlin.ru/events/president/transcripts/21444/print*

[11] *Ellen Barry, 'Putin Sounds Warning on Arms Talks',* The New York Times, *29 December 2009,* *https://www.nytimes.com/2009/12/30/world/europe/30russia.html*

[12] *Vladimir Putin, 'Presidential Address to the Federal Assembly', Kremlin.ru, 1 March 2018,* *http://en.kremlin.ru/events/president/news/56957*

[13] *'Deputy Foreign Minister Sergey Ryabkov's Opening Remarks at a Briefing at the Rossiya Segodnya International Information Agency on Arms Control and Strategic Stability', Ministry of Foreign Affairs of the Russian Federation, 11 February 2021,* *https://www.mid.ru/en/foreign_policy/news/1415641*

[14] *Tong Zhao and Dmitry Stefanovich, 'Missile Defense and the Strategic Relationship among the United States, Russia, and China',* American Academy of Arts & Sciences, *2023,* *https://www.amacad.org/sites/default/files/publication/downloads/2023_Promoting-Dialogue_Missile-Defense.pdf*

[15] *Zukang Sha, 'Can BMD Really Enhance Security?', Remarks at the Second US-China Conference on Arms Control, Disarmament and Nonproliferation, Monterey, California, 28 April 1999, cited by Brad Roberts, 'China and Ballistic Missile Defense: 1955 to 2002 and Beyond',* Proliferation Papers, *IFRI, 2004,* *https://www.osti.gov/etdeweb/servlets/purl/20759615*

[16] *Joint Declaration of the President of the People's Republic of China and the President of the Russian Federation on Strengthening Global Strategic Stability, A/70/981*–S/2016/601*, 11 July 2016,* *https://docs.un.org/en/A/70/981*

for America'.[17] The project was renamed on 24 February by amendment to 'Golden Dome for America' by decision of the White House.[18] Although the published document is brief (objectives to be achieved; policy to be followed; implementation within 60 days of publication; review of theatre missile defence systems, including those intended for allies; and general provisions), its scope is overly ambitious given the timetable set for implementing the project (2028).[19]

The 'Golden Dome for America' programme was immediately presented as a future additional layer in the country's deterrent arsenal. Section 2 of the Executive Order clearly states that the aim is to deter missile and aerial attacks against the United States (the 'homeland'). No specific adversaries are named, but '*the threat from next-generation strategic weapons […] [and] the development by peer and near-peer adversaries of next-generation delivery systems and their own homeland integrated air and missile defense capabilities*' refers to China, Russia, the Democratic People's Republic of Korea (DPRK), and Iran.[20]

As a strategic asset, the programme has been defended as a way to complicate adversaries' calculations, limit damage if deterrence fails, add new options for decision-makers, increase the credibility of deterrence, in particular in regional theatres, and serve strategic stability by securing second-strike capability.[21]

MISSILE DEFENCE AGAINST MISSILE PROLIFERATION

The shift of the 1990s

Even before the end of the Cold War, the worldwide dissemination of missiles capable of carrying WMDs created new concerns for major powers.

In the early 1980s, the spread of ballistic technologies in third countries led the Reagan administration to promote the adoption of the Missile Technology Control Regime (MTCR), an export control arrangement aimed at limiting the spread of missile technologies.[22]

Between 1982 and 1988, during the Iran–Iraq War, Iraq reportedly fired 359 Scud-Bs and five indigenous al-Husayn missiles on urban areas or military concentrations as part of a 'terror strike' approach. Tehran retaliated by procuring Scud-Bs from Libya and North Korea and launched 117 strikes between 1985 and the end of the war, with the aim of targeting strategic locations, especially in Baghdad. The poor accuracy, limited volumes used, and modest range of the Scud-B meant that these strikes did not have a major impact on the outcome of the war.[23] Nonetheless, the so-called 'war of the cities' of 1987 and the 'missile war' of 1988 raised concerns in the United States about missile proliferation.

During the first week of the Gulf War, Saddam Hussein's Iraq fired around 80 al-Husayn ballistic missiles towards Israel, Saudi Arabia, Bahrain, and Qatar. One of them, hitting Dhahran in Saudi Arabia, reportedly killed 25 American soldiers and wounded 110, accounting for more than one third of US casualties in this war.[24] Using them for the first time for this mission, the US administration boasted that PAC-2 Patriot missiles intercepted 89% of the Iraqi missiles launched towards Saudi Arabia and 44% of those aimed at Israel, a figure later deemed overly optimistic, to say the least.[25] However, an effective communication strategy presented this flawed tactical missile defence as a sort of silver bullet, able to protect the United States from any threat and to restore its freedom of action. The success of the PAC-

[17] *'The Iron Dome for America', The White House, 27 January 2025,* https://www.whitehouse.gov/presidential-actions/2025/01/the-iron-dome-for-america/

[18] *See Request for Information – Missile Defense Agency (MDA) Capabilities in response to Executive Order 'The Iron Dome for America', 31 January 2025,* https://sam.gov/opp/9da2ad63428b4ccd8aa4931c41071a3c/view

[19] *Benjamin Hautecouverture, 'Executive Order "The Golden Dome for America"',* Bulletin no. 129, *Observatoire de la Dissuasion, FRS,* https://frstrategie.org/programmes/observatoire-de-la-dissuasion/executive-order-golden-dome-america-2025

[20] *'The Iron Dome for America', op. cit.*

[21] *Kathleen Ellis, 'Re-examining National Missile Defense Strategy: Defending Against China',* Occasional Paper, *vol. 5, no. 5, NIPP, May 2025,* https://nipp.org/wp-content/uploads/2025/05/Vol.-5-No.-5.pdf

[22] *A U.S. Initiative on Missile Proliferation, National Security Decision, 1988,* https://www.reaganlibrary.gov/public/2020-12/40-413-R05-032-2020.pdf

[23] *Anthony H. Cordesman, 'The Lessons of Modern War - Volume II - The Iran-Iraq War – Chapter 13: The Air And Missile Wars And Weapons Of Mass Destruction', CSIS, 1 May 1990,* https://www.csis.org/analysis/lessons-modern-war-volume-ii-iran-iraq-war-chapter-13-air-and-missile-wars-and-weapons

[24] *JC Humphrey, 'Casualty Management: Scud Missile Attack, Dhahran, Saudi Arabia',* Military Medicine, *vol. 164, no. 5, 1999, pp. 322–26.*

[25] *Representative Les Aspin, Speech before the American Institute of Aeronautics and Astronautics, 1 May 1991, p. 4, cited in Joseph Cirincione, 'The Performance of the Patriot Missile in the Gulf War: An Edited Draft of a Report prepared for the Government Operations Committee', U.S. House of Representatives, October 1992,* https://web.archive.org/web/20031223120310/http://www.ceip.org/files/projects/npp/resources/georgetown/PatriotPaper.pdf

2 in 1991 led to the development of future programmes, in breach of the existing ABM Treaty, and fostered the idea that strategic missile defence was feasible.

In the early 1990s, many official reports were produced in the United States on the subject of missile proliferation. The alarm stemmed in particular from the fact that states investing in nuclear, chemical, or biological weapons programmes were favouring ballistic missiles as a way to deliver these non-conventional capacities.

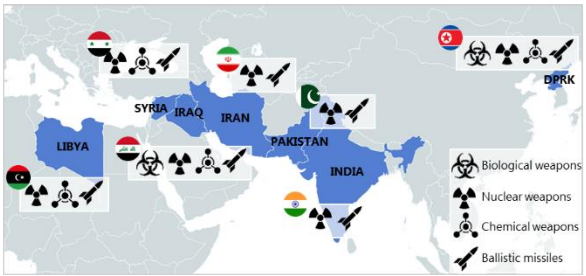


Figure 1: Conjunction of missile programmes and WMD programmes in the 1990s (Credit: FRS, mapchart.net)

A publication penned by the Department of Defense brought a new perspective on the role of missile defence: '*If [...] the U.S., its allies and friends, and even its recent adversaries like the former Soviet Union deploy effective and credible ballistic missile defenses, aggressor nations will find that large expenditures for offensive missiles only diminish their national resources while adding little to their military capability to threaten other countries. Thus, ballistic missile defenses not only will provide protection in event of attack, but also may pose a new deterrent to proliferation*.'[26]

For US officials, defensive systems were particularly suitable against proliferators, as traditional deterrence may prove ineffective. Anticipating the notion of 'rogue states', Dick Cheney affirmed in 1993 that '*[the United States] ha[s] sought to move toward the day when defenses will protect the community of nations embracing democratic values from international outlaws armed with ballistic missiles who may not be deterred by offensive forces alone*.'[27] The idea that some regimes may not be deterred because of their ideological or religious underpinning, or because they do not care about the lives of their people, was employed regularly to support a defensive option: '*If Saddam Hussein had the ability to strike a Western capital with a nuclear weapon, would he really be deterred by the prospect of a U.S. nuclear strike that would kill millions of Iraqis? Is he that concerned about his people?*'[28] In addition, the spread of defensive systems may dissuade states confronted with the ballistic threat from developing their own offensive arsenal in response, serving the goal of non-proliferation.[29]

This new focus on providing protection against or even deterring missile proliferation had technical implications, as it led the Clinton administration, in particular, to focus on theatre and tactical capacities, which could be deployed to protect US interests abroad. Programmes such as Terminal High Altitude Area Defense (THAAD) were launched during this period, while strategic programmes remained largely unfunded, to avoid strategic destabilisation. Trying to adapt theatre defence to comply with the ABM Treaty and to prevent any opposition from Russia, the Clinton administration provoked the resentment of Republican lawmakers, who denounced the Treaty as a threat to the security of US troops abroad. Progressively, proliferation became the main justification for the development of defence, and it was depicted as legitimising the withdrawal from the ABM Treaty.[30] Emphasising the efforts of some proliferators to develop long-range systems, notably North Korea but also Iran, and in a country deeply shocked by recent international terrorist attacks, the Bush administration made the decision to forego a Treaty once perceived as essential for strategic stability but now seen as ill-adapted to the emergence of new threats.

Regional endeavours

The development of missile defence in response to ballistic missile proliferation materialised in three regional contexts.

The ambitious vision of the Bush administration led to a project of layered infrastructure, with some forward deployed capacities closer to the threats. Especially concerned by the growing ballistic and WMD capacities of Iran, the Bush administration launched the concept of the 'third site', a necessary implantation in Europe of both mid-course

[26] 'Ballistic Missile Proliferation: An Emerging Threat', SDIO, DoD, 1992, https://apps.dtic.mil/sti/tr/pdf/ADA339413.pdf
[27] *Dick Cheney, 'Defense Strategy for the 1990s: The Regional Defense Strategy', Department of Defense, 1993,* https://nsarchive2.gwu.edu/nukevault/ebb245/doc15.pdf
[28] *Senate Hearing, The Administration's Missile Defense Program and the ABM Treaty, Hearings before the Committee on Foreign Relations, 107th Cong., 1st Sess., 24 July 2001 (Statement of Hon. Douglas J. Feith, Under Secretary of Defense for Policy, Department of Defense).*
[29] *Keith B. Payne, op. cit.*
[30] *'Remarks by the President to Students and Faculty at National Defense University', The White House, Washington, D.C., 1 May 2001,* https://georgewbush-whitehouse.archives.gov/news/releases/2001/05/20010501-10.html

interceptors and radars.[31] Amidst international, regional, and local controversy, the deployment site for the radar was chosen in Brdy Military Training Area, Czech Republic, and the site for the missiles in Redzikowo, Poland.[32] Changes of leadership in the countries concerned led to the cancellation of these projects. In particular, the Obama administration judged that the Iranian ICBM threat was exaggerated and that the focus should be on theatre capacities. It proposed the European Phased Adaptive Approach (EPAA) for missile defence in Europe, which had the particularity of being developed within the NATO context.

Under the first phase, the US administration deployed Aegis/SM-3 (Block IA) naval capacities in the region to address immediate threats. The second phase (around 2015) included testing and deploying enhanced capacities, in particular the land-based configuration of the SM-3 (Block IB), the third the development of the SM-3 Block IIA, and the fourth that of Block IIB, eventually cancelled in 2014.[33] After the 2010 Lisbon Summit, the system was linked to a common NATO command and control network and to the Alliance's Active Layered Theatre Ballistic Missile Defence. As part of the EPAA programme and under the NATO framework, Romania and Poland were chosen to host a US Aegis Ashore system on their territories. These sites were announced as operational in 2016 and 2024 respectively. Türkiye made public the decision to host a US-owned missile defence radar in 2011, and Spain volunteered to station US Aegis ships in the port of Rota, with the first two destroyers arriving in 2014.

These investments were clearly linked to missile proliferation, and the Chicago Summit communiqué recognised that '*should international efforts reduce the threats posed by ballistic missile proliferation, NATO missile defence can, and will, adapt accordingly*.'[34] This statement attempted to reassure Russia that the architecture under construction was not aimed at devaluing its own nuclear deterrence. In 2016, Secretary General Jens Stoltenberg thus affirmed: '*Our system is not directed against Russia. […] It will not undermine Russia's strategic deterrence. Geography and physics make that impossible. The NATO system cannot shoot down Russian intercontinental ballistic missiles from here in Romania or from Poland*.'[35] Technically speaking, the location of the missiles and their performance did not contradict this statement. But Russia's doubts were understandable, since the expected performances of the cancelled SM-3 Block IIB were close to those of a strategic interceptor, whereas the United States preserved its freedom to deploy its naval assets to an optimised position to perform interceptions. Moreover, the Missile Defense Review published by Washington in 2019 showed some noticeable changes from the 2010 Ballistic Missile Defense Review, broadening the threat addressed by missile defence. With the war in Ukraine and the adoption through NATO of the Integrated Air and Missile Defence concept, missile defence objectives now include threats from peer nuclear competitors, gradually blurring the distinction between strategic missile defence and theatre defence.[36] From this perspective, Berlin's acquisition of Arrow 3 interceptors represents a clear break from traditional perceptions of missile defence in Europe: exo-atmospheric interception was understood as the United States' responsibility, and European NATO members were supposed to focus on theatre defence with endo-atmospheric interceptors. With the Arrow 3, even if this interceptor cannot deal with ICBMs, Germany has brought Europe into the strategic defence business. The launch of the Oreshnik IRBM against a Ukrainian target illustrates the potential relevance of Germany's decision.

In Asia, the United States has worked with its closest allies on the development of missile defence capacities to face the proliferating threat from North Korea. Since the 1980s, Pyongyang has been actively working on WMD programmes as well as ballistic technologies, regularly increasing the range and accuracy of its systems. On 31 August 1998, the DPRK launched a rocket that failed to reach orbit but overflew Japanese territory, sparking a diplomatic

[31] *Tomasz Paszewski, 'US Missile Defense Plans: Central and Eastern Europe',* Revue d'études comparatives Est-Ouest, *vol. 44, no. 3, 2013, pp. 35–60,* https://shs.cairn.info/revue-d-etudes-comparatives-est-ouest1-2013-3-page-35?lang=en
[32] *Nik Hynek and Vit Stritecky, 'The Rise and Fall of the Third Site of Ballistic Missile Defense',* Communist and Post-Communist Studies, *vol. 43, no. 2, 2010, pp. 179–87.*
[33] *'Fact Sheet U.S. Missile Defense Policy A Phased, Adaptive Approach for Missile Defense in Europe', The White House, 17 September 2009,* https://obamawhitehouse.archives.gov/the-press-office/fact-sheet-us-missile-defense-policy-a-phased-adaptive-approach-missile-defense-eur
[34] *Chicago Summit Declaration issued by the Heads of State and Government participating in the meeting of the North Atlantic Council in Chicago on 20 May 2012,* https://www.nato.int/cps/en/natohq/official_texts_87593.htm#missile
[35] *Joint press point by NATO Secretary General Jens Stoltenberg with Romanian Prime Minister Dacian Cioloș and US Deputy Secretary of Defense Robert Work following the Aegis Ashore operationalisation ceremony at Deveselu base, Romania, 12 May 2016,* https://www.nato.int/cps/en/natohq/opinions_130698.htm?selectedLocale=en
[36] *NATO Integrated Air and Missile Defence Policy, Prepared by the Integrated Air and Missile Defence Policy Committee. Endorsed by NATO Defence Ministers at the 13 February 2025 Defence Ministerial in Brussels, 13 February 2025,* https://www.nato.int/cps/en/natohq/official_texts_233084.htm?selectedLocale=en

crisis and raising serious concerns in Tokyo.[37] In response, Washington and Tokyo started working on common defensive programmes, in particular regarding the Aegis/SM-3 naval system. In addition to procuring short-range PAC-3 batteries and SM-3, Japan was instrumental in the latter's development, working in particular on the nose cone and rocket engine of the Block IIA and providing funding.[38] In December 2017, Prime Minister Abe decided to procure Aegis Ashore batteries in order to improve capacity and relieve the burden on the Japan Maritime Self-Defense Force in the implementation of this mission. The plan was abandoned in 2020, however, due to domestic considerations and Japan's most recent propositions to upgrade its defensive arsenals with a focus on naval platforms.[39] Japan is also involved in the development of the Glide Phase Interceptor, intended to intercept hypersonic gliders.[40]

In South Korea, Washington forward deployed tactical missile defence to protect its own troops in the country. It tried to convince Seoul to work on a regional architecture but failed for a long time due to various concerns (fears that missile defence would weaken US extended nuclear guarantees, reluctance to integrate too closely with Japan, unwillingness to antagonise China, but also development of a national capability). However, South Korea did share the US threat assessment regarding Pyongyang's ballistic programme.[41]

As the 2014 Defense White Paper published by the ROK Ministry of National Defence indicated that the DPRK was in a position to develop an ICBM capability that could target the United States, both partners decided to increase defensive capacities on the peninsula. Despite strong debate within South Korea and in neighbouring countries, the government agreed in 2016 to deploy a THAAD system, installed in Seongju County in 2017. North Korea's rapid progress on missile technologies and its formalisation as a nuclear power led Seoul to increase its commitment to missile defence, by itself and in coordination with its partners.

In addition to cooperating on the development of enhanced systems, the United States also convinced its Asian partners to host AN/TPY-2 radars on their territory, useful for relaying information on potential North Korean ICBM launches to interceptors located in Alaska and California.

In both situations, China is concerned by these developments and considers that while they are officially aimed at responding to the DPRK threat, they could also degrade China's ability to carry out a retaliatory nuclear response. Chinese officials have therefore called out a breach of strategic stability in the region.[42]

Lastly, proliferation concerns have led to cooperative endeavours in the Middle East. From the early 2000s, US and Israeli manufacturers have worked together on the development of interception technologies. The United States provided funding for the Iron Dome programme as part of its military aid to Tel Aviv, but also for the successive Arrow and David's Sling programmes. In 2008, an AN/TPY-2 radar was deployed at Nevatim Airbase. Through joint deployment and exercises, both countries were able to improve their systems and develop an operational layered architecture to face the various missile threats in the region.

Several other Middle Eastern countries have invested in the acquisition of US systems. Under the Obama administration, an effort was undertaken to integrate the data collected from individual countries. In 2015, during the Camp David Summit, President Obama and the heads of state of the GCC countries (Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, and the United Arab Emirates) agreed to work on the creation of a region-wide ballistic missile early warning system and to conduct a table-top exercise, which took place in 2016. The Biden administration also pursued these efforts at better integration, while under each of Trump's terms, sales of US systems to regional partners increased, along with upgrades to US assets deployed in the region

[37] *'N. Korea Launches Staged Rocket That Overflies Japanese Territory',* Arms Control Today, *August 1998,* https://www.armscontrol.org/act/1998-08/press-releases/n-korea-launches-staged-rocket-overflies-japanese-territory
[38] *Sugio Takahashi, 'Ballistic Missile Defense in Japan: Deterrence and Military Transformation',* Proliferation Papers, *no. 44, IFRI, December 2012,* https://www.ifri.org/sites/default/files/migrated_files/documents/atoms/files/pp44av59takahashi.pdf
[39] *Katsuhisa Furukawa, 'Japan in Pursuit of a "New Course" for Its Missile Defence Strategy',* Open Nuclear Network, *8 January 2021,* https://opennuclear.org/open-nuclear-network/publication/japan-pursuit-new-course-its-missile-defence-strategy
[40] *Jen Judson, 'US and Japan Sign Agreement to Co-Develop Hypersonic Interceptor',* DefenseNews, *15 May 2024,* https://www.defensenews.com/global/asia-pacific/2024/05/15/us-and-japan-sign-agreement-to-co-develop-hypersonic-interceptor/
[41] *Joshua H. Pollack, 'Ballistic Missile Defense in South Korea: Separate Systems Against a Common Threat',* Missile Defense, Extended Deterrence, and Nonproliferation in the 21st Century - Collected Papers, *2 January 2017,* https://cissm.umd.edu/sites/default/files/2019-07/Paper%204%20-%20Ballistic%20Missile%20Defense%20in%20South%20Korea.pdf

[42] *Antoine Bondaz, 'Critiquer et faire face: La Chine et la défense antimissile américaine',* Recherches & Documents, *N°9/2021, FRS, April 2021,* https://frstrategie.org/sites/default/files/documents/publications/recherches-et-documents/2021/092021.pdf

(notably in Qatar and the UAE).[43] However, the Gulf countries have not yet deployed an integrated architecture and still favour bilateral cooperation with the United States.

[43] *Frank A. Rose, 'Missile Defense in the Middle East: A Smart Investment That Must Evolve',* Manara Magazine, *31 July 2025,* *https://manaramagazine.org/2025/07/missile-defense-in-the-middle-east-a-smart-investment-that-must-evolve/#_edn4*

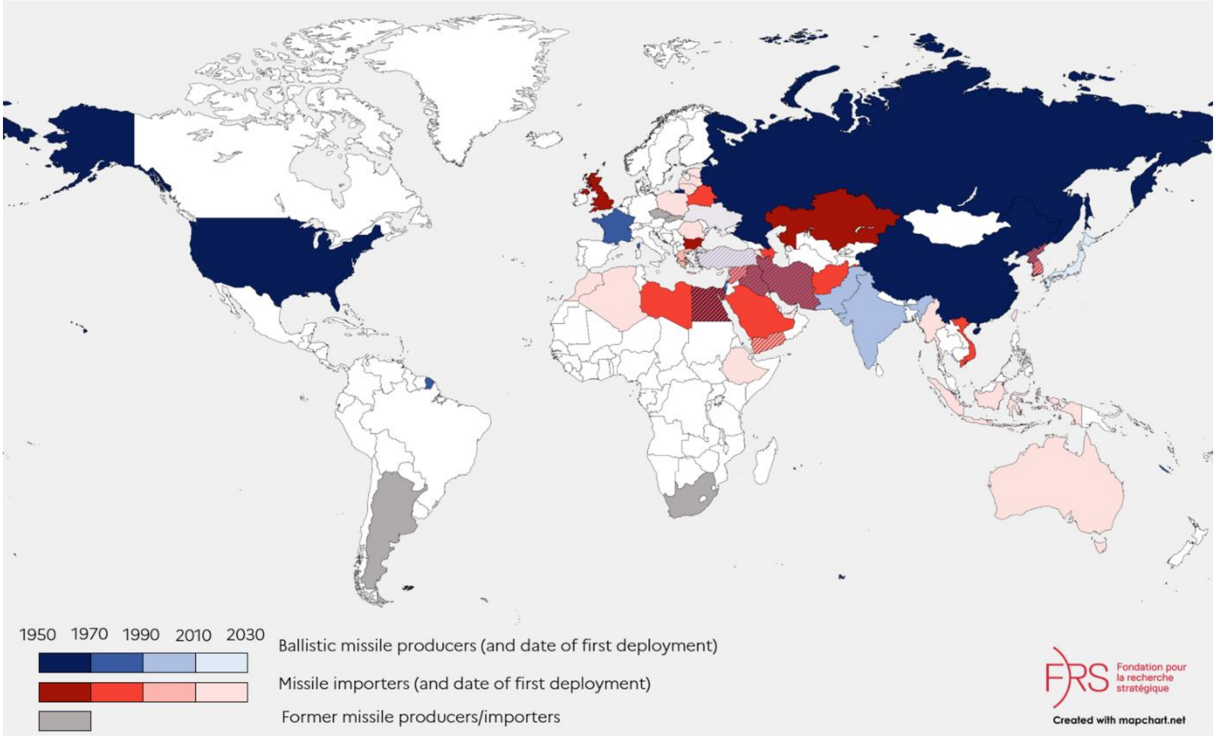


Figure 2: Ballistic missile acquisition and development programmes (Credit: FRS, mapchart.net)

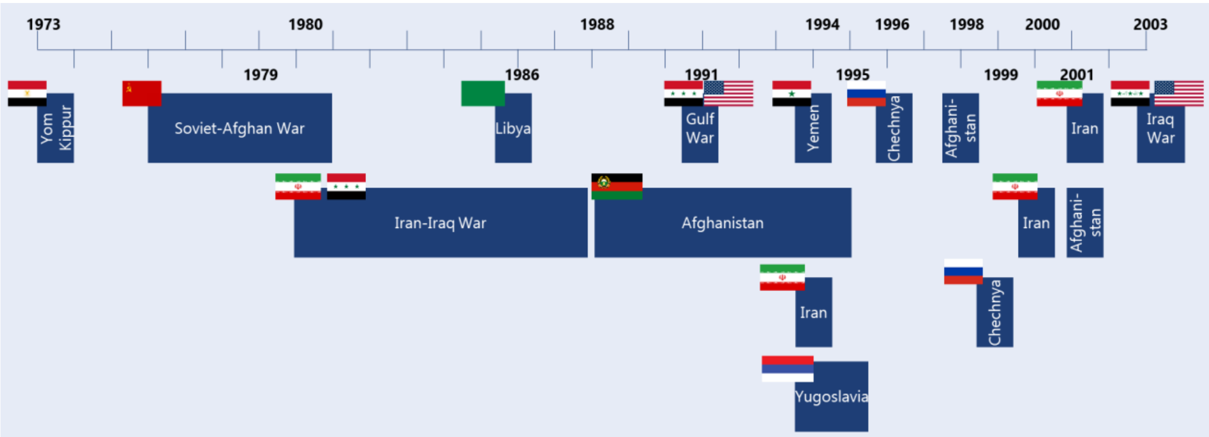


Figure 3: Conflicts during which ballistic missiles were used from 1973 to 2003 and countries that used ballistic missiles for strikes (Credit: FRS)

MISSILE DEFENCE AS A WARFIGHTING TOOL

The changing role of missiles

In the current security environment, the role of missile defence as part of the strategic stability equation and against proliferators is clearly vindicated. However, recent developments have also shown its growing appeal and role as a warfighting tool. This is due to the evolution of the role of ballistic missiles themselves.

During their first decades of existence, ballistic missiles were primarily developed as a means of delivery for WMDs. Able to reach great ranges at high speed, they were also rather inaccurate, which meant that only a warhead capable of generating major destruction could be considered as serving a military purpose. As a result, ballistic missiles were scarcely used in the twentieth century. After the first operational use of a Soviet SS-1c/Scud-B by Egypt during the Yom Kippur War in 1973, Iraq and Iran employed the same missile, as well as its North Korean copy the Scud-B,[44] to target highly populated areas in the so-called 'war of the cities', as did Afghanistan against Mujahedeen groups between 1989 and 1992. This strategy, however, was aimed more at causing psychological damage than at bringing about a military advantage. In other conflicts around the end of the Cold War or in the immediate post-Cold War period, ballistic missiles were used sporadically, including in inter-state conflicts. By the time of the first Gulf War, this situation changed with the introduction in the United States of a precise short-range quasi-ballistic system designed for conventional strike, the MGM-140 ATACMS, used in particular in Iraq in 1991 and 2003. Unlike its adversaries, the United States used this new weapon extensively for specific precision strike missions (32 missiles fired during Operation Desert Storm in 1991 and 414 during Iraqi Freedom in 2003).

In recent conflicts, the use of ballistic missiles for conventional strikes has risen sharply, alongside other strike systems. Different situations can be observed. Some countries, such as Iran, have invested heavily in building up a ballistic arsenal and have used it for long-range strikes, often aiming at demonstrating capacities or as part of retaliation strategies. Iranian non-state allies such as the Houthis in Yemen have also developed a strong ballistic arsenal (with the assistance of Tehran) and employed it on a massive scale against in-depth strategic targets, in Yemen, in Saudi Arabia, or in the UAE. Beginning in 2023, the Houthis started to aim at ships navigating in the Gulf of Aden and the Red Sea with anti-ship ballistic missiles, and at Israel using longer-range systems.

Conversely, some other countries have acquired and employed short-range precision systems for some very specific missions (for instance the destruction of a critical infrastructure or a bridge), with the high price of the systems explaining their scarce use. This is the case of Azerbaijan against Armenia, Russia against Georgia, Türkiye against Syria, Iran against US bases in the Gulf or Islamic State camps, or Israel against Iran.

The war in Ukraine has seen the emergence of new practices with regard to ballistic missiles. Russia has launched more than 950 SS-26 Iskander-M, Kinzhal, and North Korea-procured KN-23 over Ukraine since the beginning of the conflict.[45] These missiles have targeted military and civilian infrastructures such as fuel depots, but also populations, with several strikes impacting populated neighbourhoods. With the acquisition of MGM-140 ATACMS from the United States, Ukraine has also started to conduct ballistic strikes, but on a more limited scale so far and exclusively against military targets.

Missile defence and the Middle East crisis

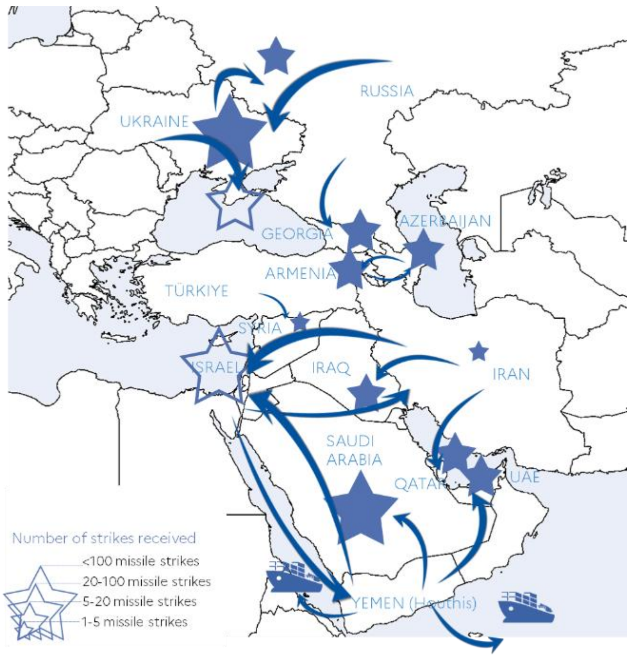


Figure 4: Use of ballistic missiles since 2017 (Credit: FRS, mapchart.net)

[44] *The term Scud-B is used to describe foreign replicas of the SS-1c, that is to say, exported North Korean models (Hwasong-5). North Korea also granted licenced production to Iran and Syria.*

[45] *Petro Ivaniuk, 'Massive Missile Attacks on Ukraine',* Kaggle, *last updated 10 November 2025.*

Beyond the two Gulf Wars, the first major conflict to involve missile defence as a crucial armament was the war between the Saudi-led coalition and the Houthis. From 2015, the Yemeni movement challenged Riyadh with ballistic missile attacks and, after 2018, with an increasing number of low-cost drones, supplied by Iran or manufactured locally (including the Shahed-136). These weapons appeared to be used for three purposes: to deny Saudi capabilities, to retaliate (strikes on the oil industry), and to divert Riyadh's resources. The Saudi defence system fulfilled its task, especially because most of these attacks remained more sequential than truly synchronised. According to a statement issued by the Saudi army in March 2021, the Houthis had launched approximately 350 missiles and 550 drone munitions up to that date. According to an estimate by Gulf State Analytics produced at the same time, the Saudis had intercepted 300 of the missiles and 350 of the drones.[46] An open-source database compiled by the CSIS documents 177 interceptions out of 270 attacks between the start of the conflict and September 2020.[47] Ultimately, the direct military and even strategic effects of the Yemeni movement's strikes have remained very limited, but the strike campaign has served to impose an exorbitant cost on Riyadh, as evidenced by additional orders of PAC-3 missiles from Washington and, above all, the order of THAAD in 2017.

Israel's missile defence has been seen as an essential capacity for decades. Iron Dome, a short-range interception system, plays an important role in suppressing the vulnerability of its population to very short-range guided rockets, completely changing the balance of power with neighbouring state and non-state actors. Iron Dome is seen as a factor of stability, at least in the eyes of Israeli society, as it allows Tel Aviv to limit military intervention on the ground and to focus its reprisals on limited air strikes. For a long time, transposing Iron Dome to strategic defence was thought to be difficult, if not impossible. The effectiveness of missile defence was recently put to the test in three waves of missile attacks from Iran. On 14 April 2024, Tehran used around 170 Shahed drones, 30 cruise missiles, and 120 liquid-fuelled MRBMs (Ghadr-1 family and Emad).[48] Iranian media announced that the main targets of the attack were the Nevatim Airbase, which houses the Israeli F-35Is, and the Ramon Airbase, where the F-16Is and Apache helicopters are stationed. This was therefore a massive strike aimed at neutralising the adversary's most effective air assets.

The attack was largely unsuccessful.[49] Most of the drones and cruise missiles were destroyed by air assets before reaching Israel's David's Sling and Iron Dome systems, recalling that missile defence is also a primary mission of the air forces. This allowed the Israeli ground-based missile defence to focus on the ballistic threat, with the help of US Navy Aegis ships in the Mediterranean, which shot down three MRBMs. This threat was itself reduced because, according to a US official, around half of the 120 MRBMs malfunctioned either during launch or in flight.[50]

On 1 October 2024, Iran displayed a change of strategy, launching mostly MRBMs. Tehran continued to target military sites as a priority. Among the estimated 181 missiles successfully launched, around 80% were reportedly intercepted, by Israel's Arrow 2 and Arrow 3 and by SM-3 positioned on board the US Navy USS Cole and Bulkeley.[51] While around 50 missiles got through and hit the Nevatim Airbase in particular, the damage was not described as major on the Israeli side, and confusion between missiles and submunitions may have caused an overestimation of missile hits. It is impossible to judge whether Tel Aviv decided to spare some interceptors and to let some missiles through when it was judged that they did not represent a real threat, as has been posited by some analysts.[52]

[46] *Riad Kahwaji, 'Saudi Air Defense Stops Most Houthi Strikes',* Breaking Defense, *30 March 2021, https://breakingdefense.com/2021/03/saudi-air-defense-stops-most-houthi-strikes/*
[47] *Shaan Shaikh, 'Yemen Conflict Update: June 16-September 16',* Missile Threat, *17 September 2020, https://missilethreat.csis.org/yemen-conflict-update-june-16-september-16/*
[48] *'Israel Says Iran Launched More Than 300 Drones and Missiles, 99% of Which Were Intercepted',* Associated Press, *13 April 2024, https://apnews.com/article/strait-of-hormuz-vessel-33fcffde2d867380e98c89403776a8ac*
[49] *Urban Coningham, 'Pulling Punches: Iran's Failed Offensive Against Israel',* Commentary, *RUSI, 15 April 2024, https://www.rusi.org/explore-our-research/publications/commentary/pulling-punches-irans-failed-offensive-against-israel*
[50] *Faris Tanyos, Cara Tabachnick, and Tucker Reals, 'Israel Says Iran's Missile and Drone Attack Largely Thwarted, with "Very Little Damage" Caused',* CBS News, *14 April 2024, https://www.cbsnews.com/news/iran-launches-drone-attack-toward-israel-idf-says/*
[51] *Steve Fetter and David Wright, 'Can the Iron Dome Be Transmuted into a Golden Dome?',* The Washington Quarterly, *vol. 48, no. 2, 2025, pp. 95–114.*
[52] *Michael Knights and Elizabeth Dent, 'Israel's Missile Defense Performance: Views from the Gulf',* The Washington Institute, *11 October 2024, https://www.washingtoninstitute.org/policy-analysis/israels-missile-defense-performance-views-gulf In general, missiles are not intercepted if they do not represent an actual threat. Some analysts have supposed that some hardened military targets may have been less defended than non-hardened civilian or military targets.*

Date	Type	Target	Result	Casualties	Sources
13/06	Around 150 missiles	Tel Aviv area	Partially successful	Around 60 people injured	https://www.timesofisrael.com/liveblog_entry/idf-estimates-that-iran-has-fired-150-missiles-at-israel-in-two-barrages/
14/06	Around 75 missiles	Haifa	Partially successful	Several dead, injured	https://www.timesofisrael.com/three-killed-near-haifa-as-iranian-missile-barrage-targets-northern-israel/
15/06	Around 90 missiles	Haifa and Tel Aviv area	Partially successful	Killed, injured	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-15-2025-morning-edition
16/06	Around 40 missiles	Haifa Power Plant, Tel Aviv area	Partially successful	Killed, injured	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-16-2025-morning-edition
16/06	10–12 missiles	Haifa area	Failure	None	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-16-2025-evening-edition
17/06	Around 50 missiles	Unknown	Unknown	Unknown	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-17-2025-morning-edition
18/06	30 missiles	Unknown	Failure	None	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-18-2025-morning-edition
18/06	One Sejjil	Unknown	Failure	None	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-18-2025-evening-edition
18/06	4 missiles	Central Israel	Failure	None	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-19-2025-morning-edition
19/06	Around 30 missiles	Beersheba, Tel Aviv, Azor	Partially successful	Around 20 people injured	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-19-2025-morning-edition
19/06	Around 15 Khorramshahr	Northern Israel	Failure	None	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-19-2025-evening-edition
20/06	Around 25 missiles	Haifa, Beersheba	Partially successful	Damages	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-20-2025-evening-edition
21/06	5 missiles	Central Israel	Failure	None	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-21-2025-morning-edition
22/06	Around 30 missiles	Haifa and Tel Aviv area	Partially successful	Several injured	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-22-2025-morning-edition
23/06	6 or 7 missiles	Ashdod and Safed	Partially successful	Damages	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-23-2025-morning-edition
23/06	14 missiles	Al Udeid Air Base, Qatar	Failure	None	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-23-2025-evening-edition
24/06	8 missiles	Beersheba, Tel Aviv area	Partially successful	4 killed, injured	https://www.understandingwar.org/backgrounder/iran-update-special-report-june-24-2025-morning-edition

Figure 5: Iranian missile strikes during the Twelve-Day War, and outcomes (Source: Institute for the Study of War)

In June 2025, the Israeli attack on Iran massively benefitted from the missile defence umbrella in order to protect the country from Iranian retaliatory strikes. According to open-source intelligence, at least 34 Arrow 3, 9 Arrow 2, and 39 THAAD interceptors were used during the Twelve-Day War.[53] Iran's missile response relied on the same types of missiles used in 2024: Emad, Haj Qasem, Kheibar Shekan, and possibly Fattah-1, but also unmanned aerial vehicles (UAVs) such as the Shahed-136. During the first night, 150 missiles were launched in two waves. The initial strike was probably mitigated by the pre-emptive destruction of launchers in Iran and the disorganisation of the C2. Nonetheless, the attacks produced more victims than in previous operations, not because of technical modification of the offence/defence balance but because Iran decided to target populated areas, such as Tel Aviv, Haifa, and Tamra.[54] Despite the potential depletion of the Israeli interceptor stockpile, the reinforcement of US assets allowed missile defence to limit the effects of the Iranian strikes. Most of all, it also opened up an opportunity for Israel to conduct major disruptive operations in the region while limiting the exposure of its population to retaliation.

[53] *Sam Lair, 'Exhaustion and Inflection: Estimating Interceptor Expenditures in the Israel-Iran Conflict [UPDATED]',* Arms Control Wonk, *24 June 2025,* https://www.armscontrolwonk.com/archive/1220527/exhaustion-and-inflection-estimating-interceptor-expenditures-in-the-israel-iran-conflict/

[54] *Ibid.*

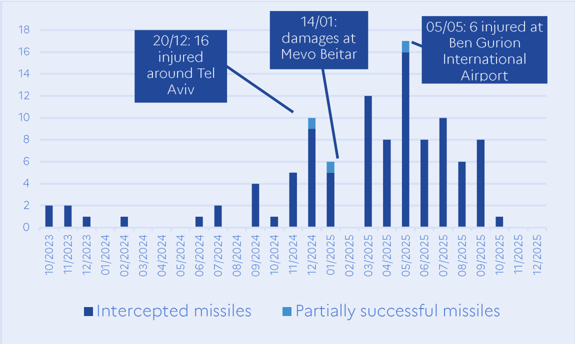


Figure 6: Houthis' missile strikes against Israel, and outcomes (2023–2025)
(Source: Institute for the Study of War)

The success of Israeli missile defence against massive strikes has another important effect. As Iron Dome does against short-range rockets, strategic defence neutralises strategies relying on harassment strikes, intended to demoralise the population and fuel political crisis in Israel. Generally operated by militias with short-range systems, the harassment strikes operated by the Houthis demonstrated a dramatic evolution, with a non-state actor capable of targeting an opponent located thousands of kilometres away. The quasi-systematic interception of the Houthis' direct strikes against Israel replicates the effects of Iron Dome against longer-range systems, with a significant impact on the power relations between the two actors.

Missile defence and the war in Ukraine

Russia's sustained long-range air and missile strike campaign is a key feature of the war in Ukraine. Since 2022, Russia has used ballistic missiles as well as cruise missiles of various kinds and drones to target military and civilian infrastructure throughout Ukraine. These strikes involve ground-, sea-, and air-launched systems. According to data analysed by the CSIS, Russia launched almost 12,000 missiles and UAVs in Ukraine from September 2022 to September 2024.[55]

While these salvos have had a limited strategic impact on the outcome of the war, their human toll in Ukraine cannot be ignored, killing and wounding thousands, mostly civilians, destroying important military and industrial capacities, and creating a permanent feeling of threat for populations subject to constant air alerts.

Ukraine's attempts to thwart the Russian missile campaign through the acquisition of missile defence assets rely heavily on foreign assistance. NATO member countries have provided different systems: in 2022, Slovakia delivered an old S-300 system, and the following year the United States sent the first MIM-104 Patriot/PAC II-III to Kyiv. Eight additional batteries were given by Germany, the Netherlands, and Romania up to 2024. Finally, Italy and France both delivered a SAMP/T battery equipped with the Aster missile, and Italy pledged a second battery in May 2024.[56] Air defence systems such as NASAMS, IRIS-T, or Gepard sent by the United States, Norway, Canada, and Germany also play a decisive role against non-ballistic targets.

From autumn 2022 and the operationalisation of some of these systems, Ukraine has been increasingly able to intercept cruise missiles and UAVs in particular. In the first half of 2022, the Ukrainian Air Force reported an interception rate of around 10% for cruise missiles, which rose to 75 to 80% in the second half of the year. In addition to the supply of systems from the West, other factors are put forward to explain this surge, such as higher skills among Ukrainian operators and the ability to predict Russian strike patterns.[57]

During that same period, Russia procured cheap Iranian Shahed-136, which it started to use on a massive scale. From 2023 onward, some 500 drones were launched monthly, most of them intercepted or failing.

Among the many delivery vehicles used by Russia, ballistic missiles have been the most sporadically used, but also the most effective. Since the beginning of the war, around 950 SS-26 Iskander-M and Kinzhal have been used against Ukraine, with an overall success rate of around 80%.[58]

It is, however, not possible to draw conclusions about the relative effectiveness or ineffectiveness of missile defence against ballistic missiles in Ukraine, as too many variables are changing or unknown: Ukrainian defences are not heterogeneous, and effectiveness depends on the targets. Defence against drones and cruise missiles is very effective, while defence against high-velocity weapons systems is more difficult, except in areas where air and missile defence is concentrated, such as in the Kyiv region. Russian

[55] *Benjamin Jensen and Yasir Atalan,* 'Assessing Russian Firepower Strikes in Ukraine', CSIS, *23 October 2024,* *https://www.csis.org/analysis/assessing-russian-firepower-strikes-ukraine*
[56] *Giorgio Di Mizio and Michael Gjerstad, 'Ukraine's Ground-Based Air Defence: Evolution, Resilience and Pressure',* Military Balance Blog, *IISS, 24 February 2025,* *https://www.iiss.org/online-analysis/military-balance/2025/02/ukraines-ground-based-air-defence-evolution-resilience-and-pressure/*
[57] *Ian Williams, 'Putin's Missile War: Russia's Strike Campaign in Ukraine', CSIS, 5 May 2023,* *https://www.csis.org/analysis/putins-missile-war*
[58] *Statistics calculated from dataset: Petro Ivaniuk, op. cit.*

ballistic or high-velocity missiles used against targets on the battlefield and its depth cannot generally be intercepted, due to the absence of defence. However, up to now, Russian ballistic operations against missile defence batteries have had very limited success, even when ballistic missiles, aero-ballistic missiles, and drones are combined. The resilience of this defence is surprising, as the existing architecture resulting from the ad hoc aggregation of different systems requires staff to undergo lengthy training in order for it to be fully operational. Ukrainian operations against Russian S-400 have also had limited results. These outcomes tend to show the overall effectiveness of defence.

It is, however, very clear that both belligerents are aiming to deplete their adversary's capacities: Ukraine hoped that Russian missile stockpiles would diminish as they were used and partially intercepted during the conflict. Nevertheless, Russia has been able to reconfigure and ramp up its ballistic missile production, and an imbalance between offence and defence is emerging in favour of Russia. Moreover, Russia has been sending waves of cheap means of delivery to deplete the number of interceptors held by Ukraine and put pressure on its Western partners to refuel Kiyv. This evolution raises questions about the industrial ability of Western countries to catch up with Russia. Indeed, each ballistic interception requires at least two missiles for one target, while quasi- and aero-ballistic missiles demand much more.[59] Defence is more consuming than offence and is not viable in the long term unless it is coupled with long-range strike capabilities used against offensive weapons systems but also against production assets.

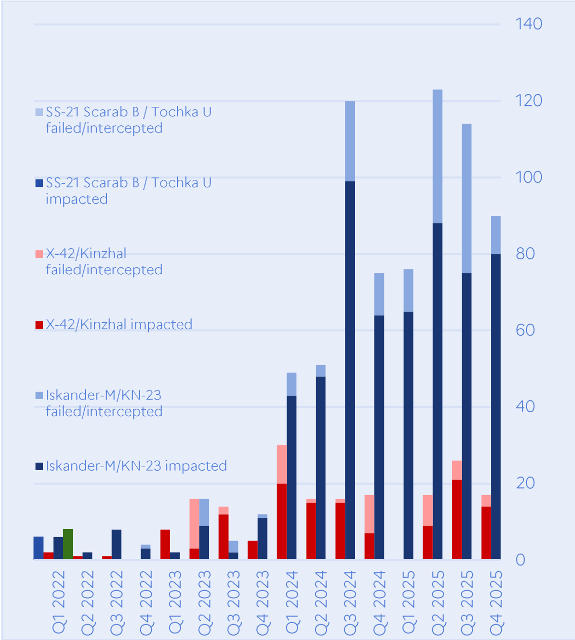


Figure 7: Use of ballistic missiles by Russia during the war in Ukraine, and rates of interception of various missiles (2022–2025) (Source: Petro Ivaniuk)

It should be underlined that tactical and operational strikes have strategic consequences in this conflict. The attrition of Ukrainian defence is detrimental to the troops on the ground but also to economic and military infrastructure deeper in Ukrainian territory. In the same way, Ukrainian air and missile defence, which is constructed around point defence weapons systems and is not per se strategic defence, is in fact a strategic asset.

In the Ukrainian theatre, the critical role of long-range strike systems and of air and missile defence generates a 'strategic' arms race of tactical and operational systems, which in turn pushes the surrounding countries to develop similar and longer-range weapons systems, for offence as well as for defence. More European countries may opt for strategic defence, as Germany has done, in order to build layered architectures covering their troops, their military assets, and their populations. In turn, Russia will likely increase its number of long-range precision strike systems. Unfortunately, the pressing need to ramp up tactical and operational defence in Europe will accelerate a conventional arms race that cannot easily be halted.

[59] *According to recent Ukrainian declarations, SS-26 Iskander-M were essentially used in a ballistic configuration rather than a quasi-ballistic one, facilitating their interception. 'Russia Upgrades Iskander-M Missiles, Making Them Harder to Intercept — Ukrainian Air Force Spokesman',* Defense Express, *25 May 2025, https://en.defence-ua.com/news/russia_upgrades_iskander_m_missiles_making_them_harder_to_intercept_ukrainian_air_force_spokesman-14627.html*

Technical definitions and categorisation of missile defence systems

Missile defence systems are traditionally divided into three categories: **strategic, theatre, and point defence**. These categories are partly normative and partly empirical. The ABM Treaty defines a **strategic system** as a system whose interceptor has a velocity greater than 3 km/s and is capable of engaging a target with a velocity greater than 5 km/s and a range greater than 3,500 km. In 1997, Russia and the United States agreed that the interceptor speed must be greater than 5.5 km/s for a ground-based system and 4.5 km/s for a naval system. Below these characteristics, a missile defence system was defined as non-strategic. The abandonment of the ABM Treaty rendered these specifications obsolete, but they still provide a useful technical reference.

The interceptor speeds defined as 'strategic' by the ABM Treaty can only be achieved by exo-atmospheric vehicles, which explains why the latter are generally associated with strategic interception. In fact, exo-atmospheric interception can occur against missiles flying at speeds well below 5.5 km/s, provided that the exo-atmospheric phase of the missile is long enough to allow interception.

A **theatre interceptor** is generally defined as capable of intercepting MRBM and IRBM targets with velocities below 6 km/s. The interceptor is defined as 'theatre' because its intercept footprint is sufficient to cover relatively large geographical areas of up to thousands of square kilometres. Theatre missile defence generally relies on exo-atmospheric systems, with the exception of the American THAAD, which can operate in the lower exo-atmosphere but also in the upper endo-atmosphere.

Point defences, which only cover restricted areas, are associated with terminal defences in the lower endo-atmosphere. These are generally interceptors designed to engage SRBMs and MRBMs, with current interceptors capable of engaging targets up to 1,300 km away at a speed of 3.2 km/s. However, some point defence systems can also be used to intercept strategic missiles. The Russian 53T6 Gazelle interceptor, part of Moscow's ABM belt, is designed to intercept an ICBM at an altitude of less than 50 km at an estimated speed of 4 km/s.

The fluidity of this categorisation is also reflected in the concept of strategic interception or strike, which is essentially linked to the range of a missile in cases where the strike is carried out between countries that are very far apart. In specific regions, other definitions may be considered. The MTCR, which was originally based on threats identified in the Middle East, specifically the SS-1c (Scud), defines 'strategic' range as 300 km, with a missile speed of 1.5 km/s. A relatively slow interceptor, with a speed of 1.3 km/s, is capable of dealing with this type of target. In limited-scale theatres of operation, non-strategic interceptors therefore have strategic functions. The Iron Dome system, designed to intercept very short-range, low-speed targets, is an excellent illustration of this, and its deployment has had a considerable impact on Israeli security policy.

Moreover, with the evolution of technology, interceptors defined as non-strategic are gradually acquiring strategic specifications according to the old categorisation of the ABM Treaty. While in the 1990s a PAC-2 missile could only intercept a Scud with difficulty, a PAC-3 MSI is capable of successfully intercepting a missile with a range of over 1,000 km. Although the specifications of both the interceptor and its target are still well below the Treaty limits, the SM-3 Block IIA, defined as a theatre interceptor system, is capable, under specific conditions, of intercepting an ICBM travelling at speeds of between 6 and 7 km/s. In addition, the reduction in the number of components now makes it possible to design small, mobile systems similar to point defence systems but with specifications close to those of a strategic interceptor, such as the Israeli Arrow 3.

These developments make it difficult to characterise an interceptor for regulatory purposes, especially as the evolution of conventional strike systems, which in this particular case is reflected in increased range and speed, requires a parallel evolution of interceptors, tending to give them strategic characteristics by default, even though their main mission is conventional defence. The most enduring characteristic remains the interception domain (endo- or exo-atmospheric), even if the development of hypersonic weapons is making atmospheric interception increasingly strategic.

CURRENT DEPLOYMENTS AND PROJECTS

Around forty countries are currently deploying ballistic missile defence assets, and the list is growing rapidly as more and more states are interested in buying systems off-the-shelf to respond to a perceived missile threat.

Tactical interception

By far the most widespread systems are endo-atmospheric missiles intercepting short- or medium-range systems in the terminal phase of their flight. This is in particular the case of systems produced by the United States (MIM-104 Patriot/PAC II-III, SM-6), Russia (S-300/S-400), France, Italy, and the United Kingdom (Aster-30/PAAMS-Sea Viper), or Israel (Barak 8, David's Sling, and Iron Dome). All of these systems have been exported or are in the process of being exported. For instance, fifteen countries are currently operating the MIM-104 Patriot/PAC II-III in Europe, Asia, and the Middle East.[60] Designed by Raytheon and manufactured by Raytheon, Lockheed Martin, and Boeing, the system has seen several upgrades (PAC II, PAC II GEM/GME-T, PAC III, PAC-3 CRI, PAC-3 MSI...), each of them enabling the interception of ballistic targets of greater speed and range. The Aster-30 interceptor, manufactured by the Eurosam consortium (MBDA and Thales), which exists as a land and a naval system, has been widely exported.[61] Finally, regarding the Barak 8, a short-range intercepting system co-developed by India's Defence Research & Development Organisation (DRDO) and Israel Aerospace Industries, current operators include three countries, with more sales announced.[62] Israel is also marketing its David's Sling, with Finland becoming the first foreign buyer in November 2023.[63]

China (HQ-9, HQ-29) and South Korea (KM-SAM) have produced their own national tactical missile defence assets.

Theatre architectures

In addition to these tactical systems, which can also be designed to defend against aircraft, UAVs, or cruise missiles, states are also developing and deploying theatre missile defence systems. These are aimed at defending a wider region against ballistic threats and use the whole spectrum of interception possibilities, from terminal interception to re-entry and mid-course, and may be endo-atmospheric or exo-atmospheric.

In this category, the most well-known systems are the US Army THAAD, manufactured by Lockheed, and the US Navy Aegis. The THAAD is operated by US units in foreign countries, especially in Asia (South Korea) and the Middle East (Israel, UAE). The UAE and Saudi Arabia have ordered their own batteries, with the UAE becoming the first foreign user to make operational interceptions in 2022.[64] Saudi Arabia's first battery was inaugurated in July 2025.[65]

The Aegis system exists in three variants at this stage (SM-3 Block IA, currently being replaced by the Block IB, and the Block IIA, used against longer-range

[60] *Germany, Greece, Netherlands, Romania, Spain, Sweden, Ukraine, Japan, Taiwan, Egypt, Jordan, Kuwait, Qatar, Saudi Arabia, and the United Arab Emirates. Additional sales have been contracted with Morocco, Poland, and Switzerland. 'Patriot Missile Long-Range Air-Defence System, USA',* Army Technology, *1 March 2024,* https://www.army-technology.com/projects/patriot/?cf-view
[61] *Sold to Egypt, Greece, Qatar, and Singapore, and lent to Ukraine.*
Sébastien Roblin, 'France and Germany Are Beefing Over Air Defense Batteries', Popular Mechanics, *23 June 2023,* https://www.popularmechanics.com/military/weapons/a44287853/france-germany-dispute-mamba-air-defenses-ukraine/
[62] *Exports confirmed to Azerbaijan, Cyprus, and Morocco. Brandon J. Weichert, 'India Dreams of Israel's Barak-MX Missile Defense System',* The National Interest, *10 April 2025,* https://nationalinterest.org/blog/buzz/india-dreams-of-israels-barak-mx-missile-defense-system
New sales announced to Greece, the Netherlands, and Slovakia.
'Greece in Talks with Israel's IAI over Barak Air Defence Systems Under Achilles Shield Plan', Defence Industry Europe, *5 April 2025,* https://defence-industry.eu/greece-in-talks-with-israels-iai-over-barak-air-defence-systems-under-achilles-shield-plan/
Rudy Ruitenberg, 'Dutch Navy to Buy Armed Sidekick Ships for Its Air-Defense Frigates', DefenseNews, *25 September 2024,* https://www.defensenews.com/global/europe/2024/09/25/dutch-navy-to-buy-armed-sidekick-ships-for-its-air-defense-frigates/
Seth J. Frantzman, 'Israel Signs $583 Million Deal to Sell Barak Air Defense to Slovakia', Breaking Defense, *24 December 2024,* https://breakingdefense.com/2024/12/israel-signs-583-million-deal-to-sell-barak-air-defense-to-slovakia/
[63] *Emanuel Fabian, 'Israel Signs Landmark Deal to Sell David's Sling Air Defense System to Finland',* The Times of Israel, *12 November 2023,* https://www.timesofisrael.com/israel-signs-landmark-deal-to-sell-davids-sling-air-defense-system-to-finland/
[64] *Jeremy Binne, 'CENTCOM Commander Confirms UAE Successfully Used THAAD',* Janes, *9 February 2022,* https://www.janes.com/osint-insights/defence-news/weapons/centcom-commander-confirms-uae-successfully-used-thaad
[65] *Shir Perets, 'Saudi Arabia Activates US THAAD to Deter Looming Iran Missile Threat',* The Jerusalem Post, *3 July 2025,* https://www.jpost.com/middle-east/article-859842

missiles). The SM-3 is a ship-based midcourse interceptor deployed on US and Japanese ships, with South Korea having decided in 2024 to equip its future destroyers with the system. Finally, as part of NATO's Integrated Air and Missile Defence Policy, Aegis Ashore SM-3 systems have been built on Polish and Romanian territory and are operated by NATO.[66]

Israel has also actively developed these types of capabilities, with the Arrow 2 and the Arrow 3. In this category, Russia is currently working on the S-500, India on the Prithvi Defence Vehicle, and China on the HQ-19 and HQ-26.

Strategic missile defence

The major countries investing in missile defence have also deployed basic strategic capacities. Some are relatively old, such as the Russian A-135, which entered service in 1995 and succeeded the A-35, with its main mission being the protection of Moscow. Its endo-atmospheric interceptor missiles are thought to be loaded with nuclear warheads. Under the modernisation plan of the system known as A-235, Russia is reportedly working on a three-tiered system operating with exo-atmospheric and endo-atmospheric interceptors equipped with nuclear but also conventional interceptors. The Nudol direct-ascent anti-satellite (ASAT) weapon, tested in 2021, may also be used as an interceptor in the future, as some derived systems seem to be in development.[67] The integration of the future S-500 in this architecture is still unclear.

On the Chinese side, the development of ASAT weapons and long-range interceptors for strategic defence is also intertwined. The Dong Neng-3 and the SC-19 seem the closest to deployment. The Dong Neng-3 has been tested in 2018, 2021, and 2023, especially against MRBMs.[68] According to available information, the SC-19 mid-course interceptor was tested most recently in April 2023.[69]

Israel fields the Arrow 3 system, which is understood to be able to intercept IRBMs. Developed by Israel Aerospace Industries and Boeing, the Arrow 3 is the only system in this class to have been used in combat. It successfully intercepted a Houthi missile heading towards Eilat on 9 November 2023,[70] and two others in September 2024.[71] It was also reportedly used against Iranian missile attacks in April 2024, October 2024, and June 2025.[72]

Interestingly, Germany has acquired the Arrow 3 system, as part of ESSI. The sale was approved in November 2023, and the first deliveries are still planned for the end of 2025, despite the conflict between Israel and Iran.[73]

Lastly, while US ambitions have been both long-standing and broad, only one programme can currently be regarded as operational. In the framework of the Ground-Based Midcourse Defense (GMD), the United States is deploying Ground-Based Interceptors (GBIs) based on a multistage booster and exo-atmospheric kill vehicle. Forty missiles are deployed at Fort Greely, Alaska, and four at Vandenberg Space Force Base, California. Twelve successful interceptions have been reported since 1999, out of 21 tests. A third site is to be built on the East Coast, with additional GBI-type missiles.[74] The GBI, now considered obsolete against North Korean ICBMs, will be replaced by the Next Generation Interceptor (NGI). The NGI will be more powerful and associated with multiple kill vehicles. This technology, still immature, could bring a decisive capability to current strategic defence, allowing the destruction of several warheads with a single interceptor. It will probably also rely on the deployment of a space architecture.

Golden Dome aims at strengthening this dimension. It is based on the Proliferated Warfighter Space Architecture (PWSA), a space architecture concept

[66] *'U.S. Missile Defence Base in Poland Now Officially in NATO's Structures'*, PISM, *14 November 2024*, https://pism.pl/publications/us-missile-defence-base-in-poland-now-officially-in-natos-structures
[67] *Jacob Mezey, 'Russian and Chinese Strategic Missile Defense: Doctrine, Capabilities, and Development'*, Issue Brief, *Atlantic Council, 10 September 2024*, https://www.atlanticcouncil.org/in-depth-research-reports/issue-brief/russian-and-chinese-strategic-missile-defense-doctrine-capabilities-and-development/
[68] *'China Says Conducted Mid-Course Missile Interception Test'*, Associated Press, *15 April 2023*, https://apnews.com/article/china-interceptor-missile-test-defense-c77ae53a43f5e74bc48c4be45e46af80
[69] *'SC-19 Anti-Ballistic Missile Interceptor'*, Global Security, *14 April 2023*, https://www.globalsecurity.org/space/world/china/sc-19-abm.htm
[70] *Emanuel Fabian, 'Israel's Arrow 3 Has Made Its 1st-Ever Interception, Downing Likely Yemen-Fired Missile'*, The Times of Israel, *9 November 2023*, https://www.timesofisrael.com/liveblog_entry/israels-arrow-3-has-made-its-1st-ever-interception-downing-likely-yemen-fired-missile/
[71] *Yonah Jeremy Bob, 'Yemen's Houthis Fire Missile at Central Israel, Missile Breaks up Within Israeli Airspace'*, The Jerusalem Post, *15 September 2024*, https://www.jpost.com/breaking-news/article-820120
[72] *Sam Lair, op. cit.*
[73] *Tzally Greenberg, 'Israel Enters Final Phase to Deliver Arrow-3 Missile Shield to Germany'*, DefenseNews, *9 June 2025*, https://www.defensenews.com/global/europe/2025/06/09/israel-enters-final-phase-to-deliver-arrow-3-missile-shield-to-germany/
[74] *'Current U.S. Missile Defense Programs at a Glance'*, Arms Control Association, *last reviewed January 2025*, https://www.armscontrol.org/factsheets/current-us-missile-defense-programs-glance#gbmd

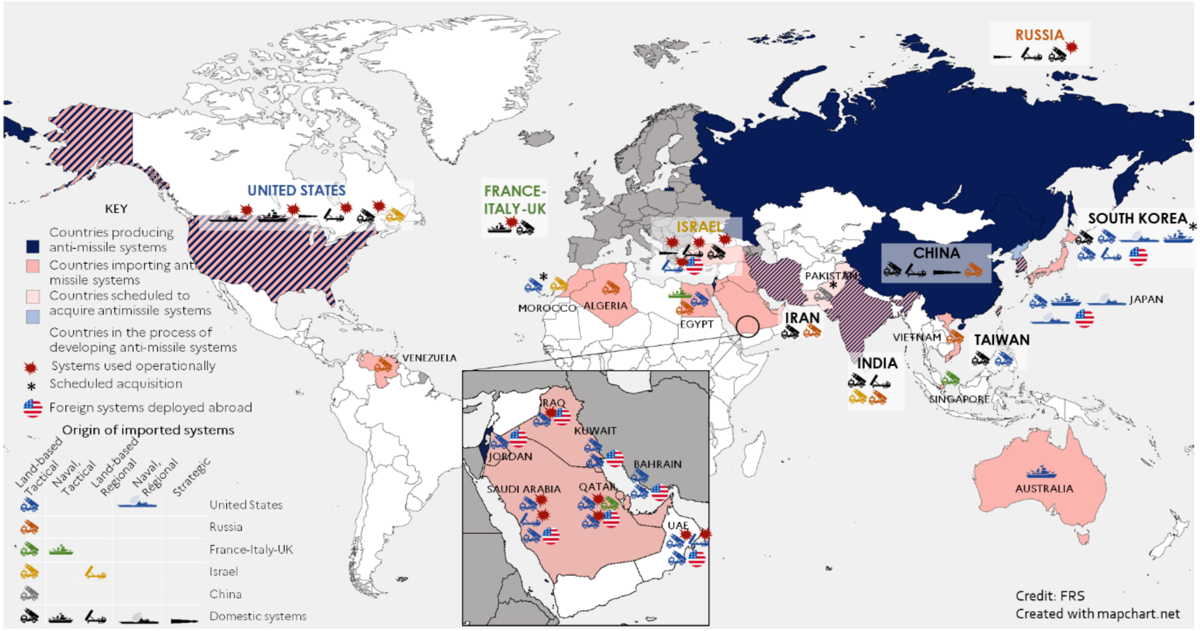
organised around a communications constellation, known as the *Transport Layer*, an alert and trajectory constellation, known as the *Tracking Layer*, and a constellation of sensors that can be modulated according to user requirements, known as the *Custody Layer*. By increasing the number of space sensors for the detection and tracking of missiles and warheads, by reducing the latency in communication between satellites, C2, and weapons systems, and by processing data in space, the PWSA should have a significant effect on the interception missions of the land and naval components (NGI, SM-3, and THAAD interceptors).

The specificity of Golden Dome also lies in the development of space-based interceptors, described as capable of intercepting ballistic missiles during their propulsion phase. This aims at avoiding the discrimination problems linked to an engagement that occurs after the separation of the warhead (or the bus carrying the warhead) from the last stage, followed by the deployment of penetration aids. Technically, this ambition seems difficult to achieve, at least with kinetic interceptors, as the engagement cycle is too long to allow for interception during the propulsion phase. Golden Dome will therefore probably favour the development of non-kinetic systems.

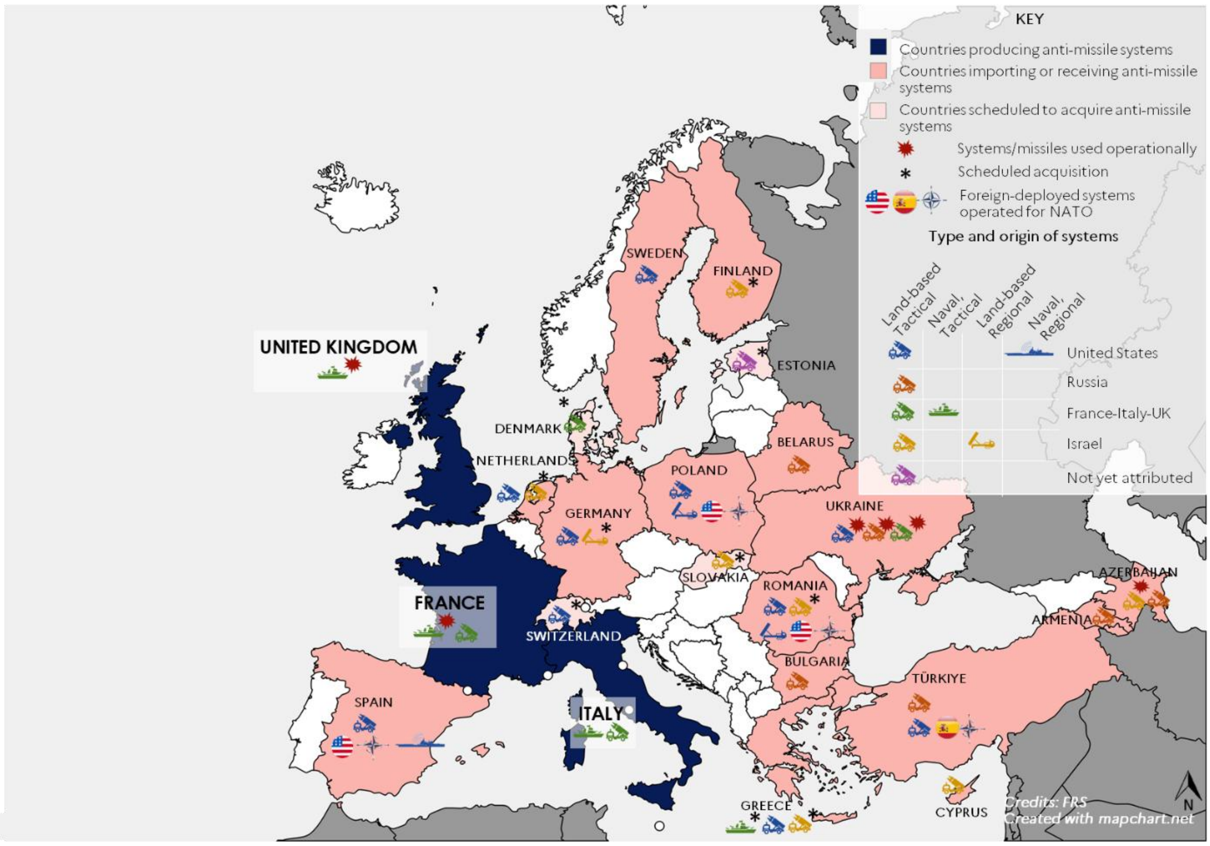
The project also includes a ground segment, through the strengthening of strategic interception systems (NGI) and the development of systems capable of engaging hypersonic assets (Glide Phase Interceptor, launched by the previous administration, and adaptation of the SM-6). There have also been proposals to develop terminal interceptors, probably operating between high endo-atmospheric and low exo-atmospheric altitudes, whose primary mission would be to protect nuclear sites (silos, bases, etc.).

However, the United States does not have a suitable missile for this particular mission and would therefore have to design a new system if this project were to go ahead. This part of the programme, less commented upon, and yet crucial, could enable the United States to have a more effective defence layer than the one currently in place.[75]

[75] *Stéphane Delory, 'Golden Dome: Vers une nouvelle ère d'instabilité stratégique?',* Défense & Industries, no. 21, *FRS, July 2025,* https://frstrategie.org/publications/defense-et-industries/golden-dome-vers-une-nouvelle-ere-instabilite-strategique-2025



Figures 8 and 9: Ballistic missile defence systems deployed and imported (world and Europe) (Credit: FRS, mapchart.net, Sources: Military Balance, IISS)



CHAIN REACTIONS: IMPLICATIONS OF MISSILE DEFENCE ON OFFENSIVE MISSILE ARSENALS

In 1999, the US National Intelligence Council shared its projections regarding upcoming foreign missile developments: '*We assess that countries developing missiles also will respond to US theater and national missile defenses by deploying larger forces, penetration aids, and countermeasures*.'[76] The relationship between defensive arsenals and offensive arsenals is self-explanatory and is based on the ancestral dialectic between the shield and the sword. Three distinct phenomena can be described: quantitative developments, qualitative adaptation, and missile-space interlinkage.

HOPING TO SATURATE: QUANTITATIVE RESPONSE

An expected reaction to missile defence may be the quantitative development of offensive missiles, with the hope of saturating defensive systems.

Offence–defence arms race dynamics

As missile defence has the potential to degrade nuclear strike capacity and therefore deterrence, both the United States and the Soviet Union realised in the early 1960s that if their adversary invested in this type of armament, they would have to increase their offensive arsenal in response.

Compensating for stronger defence by enhancing offence appears feasible for two reasons. First, the interceptors required/ICBMs launched ratio is favourable to the attacker. Thus, US programme managers suggested that two to four interceptors should be necessary to intercept single-warhead ICBMs. Second, the price tag of offensive missiles should be lower than that of defensive missiles.[77]

This conclusion still applies today,[78] according to recent calculations conducted independently. A team of researchers established the following costs for various systems, trying to estimate comparable data. In the best-case scenario (interception rate of 90%, discrimination of countermeasures and decoys), the defender would spend eight times more than the attacker. In a more pessimistic scenario (50% interception rate, two interceptors required per warhead), defence would be 70 times more costly. According to these calculations, the individual estimated costs of US, Russian, Chinese, or other ICBMs remain systematically below the cost of interceptors such as the GBI or SM-3.[79] This assessment is even more obvious if we compare the price of the SM-3 with that of less sophisticated MRBMs, such as the Ghadr missiles used by Iran in its strikes on Israel and on US assets in the Gulf.

Interceptors	Estimated cost per interception ($)
Next Generation Interceptor (NGI)	111,000,000
Ground-Based Interceptor (GBI)	90,000,000
Standard Missile 3 (SM-3) Block IIA	27,915,625
Standard Missile 3 (SM-3) Block IB	9,698,617–12,500,000
Standard Missile 6 (SM-6)	9,574,400
Patriot PAC-3	3,729,769
Arrow 3*	3,000,000
Standard Missile 2 (SM-2) Block IV	2,100,000
Aster-30 (SAMP-T)	2,000,000

Figure 10: Comparison of missile interceptors by cost (Source: MDAA)

**The Arrow 3's cost per unit, as announced by the manufacturer, may appear surprisingly low in comparison to other systems, and its price may not include all related equipment.*

Fear of an arms race can be found early on in US and Soviet thinking on missile defence and the possibility of arms control. Jerome Wiesner, scientific advisor to

[76] National Intelligence Council, 'Foreign Missile Developments and the Ballistic Missile Threat to the United States Through 2015', September 1999, https://irp.fas.org/threat/missile/nie99msl.htm
[77] J. P. Ruina and M. Gell-Mann 'Ballistic Missile Defense and the Arms Race'. In: Philip Bobbitt, Lawrence Freedman, and Gregory F. Treverton, eds., US Nuclear Strategy, Palgrave Macmillan, 1989.
[78] 'Missile Interceptors by Cost', MDAA, February 2024, https://missiledefenseadvocacy.org/missile-defense-systems-2/missile-defense-systems/missile-interceptors-by-cost/
[79] Igor Moric and Timur Kadyshev, 'Forecasting Costs of U.S. Ballistic Missile Defense Against a Major Nuclear Strike', Defense and Peace Economics, vol. 36, no. 2, 2025, pp. 141–66, https://www.tandfonline.com/doi/full/10.1080/10242694.2024.2396415#abstract

President Kennedy, was one of the first to theorise the risk that defensive capacities may lead to an increase in adversary offensive weapons without assuring protection against the latter.[80] In the context of the Vietnam War, Secretary of Defense Robert McNamara eventually opted against the development of defensive programmes against Soviet forces because of their high cost, which, as he put forward to President Johnson, were way above those of ICBMs and offered limited effectiveness. In addition, McNamara (and his Republican successor in the Nixon administration) was convinced that an ambitious US anti-missile umbrella would lead Moscow to strengthen its ballistic arsenal but also to work on its defensive capacities, which would then mean that the United States would have to increase its offensive arsenal, creating additional expenses.[81] The inability of defensive capacities to prevail in this arms race was reinforced by the introduction of MIRVs.[82]

In the Soviet Union, despite initial investments, a conviction also rapidly emerged that the development on both sides of defensive architectures aimed at each other would not be sustainable. For both countries, facing budgetary pressure, limiting defences through mutually agreed limits was a way to avoid spending millions in armament and led to the negotiation of the ABM Treaty.[83]

During the debate on the SDI, the Soviet Union used the same types of arguments and predicted an upcoming arms race, especially in space: 'If you create space strike weapons we shall do the same.'[84] Following Reagan's announcement of the SDI, American analysts expected the Soviet Union to increase the number of missiles and to add re-entry vehicles to its boosters. They also predicted greater investment in missile defence programmes. However, some economists noted that the USSR would be reluctant to commit to a brand-new, ambitious R&D programme on these technologies due to Gorbachev's efforts to focus on economic recovery and the difficulty of the Soviet military industry to adopt a disruptive and innovative approach.[85]

While theoretical modelling anticipated an increase in offensive capacities linked to the SDI, and therefore an arms racing phenomenon,[86] analytical evidence was hard to gather. The Soviet strategic arsenal did increase following Reagan's announcement, but these new deployments could not have been the result of short-term decision-making. On the other hand, it decreased from 1987 in the context of bilateral arms control.[87]

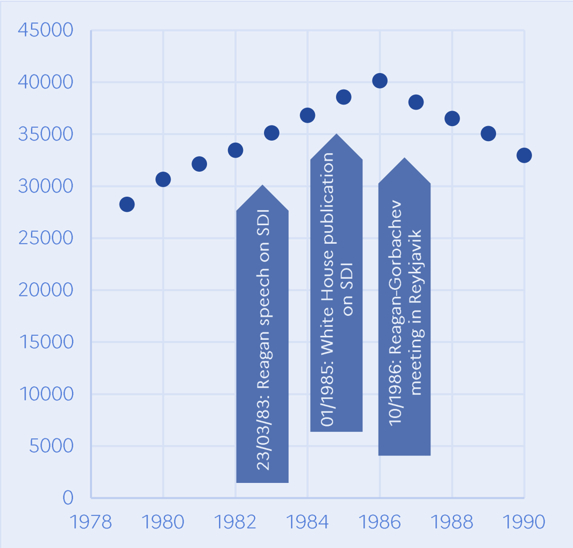


Figure 11: Change in the number of nuclear warheads held by the Soviet Union (1978–1990) (Source: FAS)

Despite a lack of evidence, the arms race resulting from the SDI has actually been used by supporters of Reagan to argue for the programme's instrumental role in helping the United States win the Cold War. Three arguments have been put forward to defend this thesis: unable to keep up with US technological developments, Moscow was forced to negotiate; the Soviet Union bankrupted itself in trying to respond militarily to the SDI; or the Soviet Union was pushed towards perestroika to recover some form of economic leverage.[88] These simplistic arguments were never proven, and the Soviet decision to stop the arms race and to negotiate a far-reaching arms control agreement was mostly linked to domestic

[80] Anti-Ballistic Missile: Yes or No? A Special Report from the Center for the Study of Democratic Institutions, *Hill and Wang, 1968.*
[81] *Robert McNamara, 'Draft Memorandum From Secretary of Defense McNamara to President Johnson', Foreign Relations of the United States, 1964–1968, Volume X, National Security Policy, Office of the Historian, 22 December 1966.*
[82] *Robert Kleiman, 'MIRV and the Offensive Missile Race',* The New York Times, *9 October 1969,* https://www.cia.gov/readingroom/docs/CIA-RDP70B00338R000300110010-2.pdf
[83] *Cable, Gerard C. Smith to Henry A. Kissinger, Top Secret/Eyes Only, Excised Copy, 8 December 1971,* https://nsarchive2.gwu.edu/NSAEBB/NSAEBB60/abm21.pdf
[84] *David E. Morgan, 'An Analysis of the Soviet Response to the Strategic Defense Initiative', 87-1800, Air Command and Staff College, Air University, April 1987,* https://apps.dtic.mil/sti/tr/pdf/ADA181220.pdf
[85] *Ibid.*
[86] *Alvin M. Saperstein and Gottfried Mayer-Kress, 'A Nonlinear Dynamical Model of the Impact of SDI on the Arms Race',* Journal of Conflict Resolution, *vol. 32, no. 4, December 1988, pp. 636–70.*
[87] *Hans Kristensen, Matt Korda, Eliana Johns, Mackenzie Knight-Boyle, and Kate Kohn, 'Status of World Nuclear Forces', FAS, 26 March 2025,* https://fas.org/initiative/status-world-nuclear-forces/
[88] *Luigi L. Lazzari, 'The Strategic Defense Initiative and the End of the Cold War',* Naval Postgraduate School, *March 2008,* https://core.ac.uk/download/pdf/36697931.pdf

decisions—some of them correlated to the burden of defence spending on the Soviet economy—but not specifically resulting from fear of the SDI.[89]

The debate on the causality of missile defence on the arms race is still ongoing today. On the political level, recent Russian declarations clearly indicate a willingness to respond quantitatively to the perceived threat posed by missile defence. Thus, in 2018, Putin indicated that Russia must develop new offensive weapons to counter the United States' missile shield.[90] Very visibly, the Chinese nuclear build-up has been linked to missile defence deployments. Since the 2000s, several articles have demonstrated that China was losing confidence in its offensive nuclear capabilities due to the development and deployment of a US strategic missile defence system. The main argument obviously focuses on the consequences of a first strike and the risk of interception of residual forces, with the survivability of Chinese nuclear forces deemed '*extremely limited*'.[91] While China refused for a long time to acknowledge that increasing its arsenal may be a way to counter that threat and preserve second-strike capability,[92] official documents from 2013 onwards show that a 'strong' arsenal was seen as a necessity, endorsed by Xi Jinping in October 2022.[93]

In the context of the Golden Dome announcement, the link between US investment in missile defence and nuclear build-up by its competitors has been discussed. Conservative analysts consider that this link is a 'myth' and that the increase in offensive systems is occurring independently of any US development, as these countries are striving for nuclear dominance as a strategic and political objective.[94] Historical evidence has also been used to show the lack of direct correlation.[95] These affirmations tend to neglect the fact that overcoming missile defence is above all a question of the ratio between offence and defence. Increasing the number of missiles or warheads on missiles remains the only proven way of overwhelming defences. Assuring the destruction of a defended strategic target naturally requires the use of more warheads than the destruction of an undefended target. Conservative analysis therefore tends to downplay the development of arsenals in the framework of an arms race of offensive systems (US–Soviet competition) or in the framework of an emerging ballistic programme (such as the North Korean one), with existing arsenals being adapted to missile defences. North Korea, Iran, but also Russia (at least in Ukraine) are vivid examples of the adaptation of offensive capabilities to defensive deployments, even if in all cases other factors may also contribute to the increase in arsenals.

Additional weapons developed to achieve a saturation effect

At the tactical and theatre level, countering defence through the accumulation of offensive capacities underpins saturation strategies. This is obviously the approach pursued by Iran, with the launch of dozens of missiles at the same time, hoping to not only exhaust interceptors but also saturate captors. In addition, launches in salvo put pressure on systems and their ability to convey information and organise adequate responses, due to the overexploitation of information networks but also of human resources assigned to the task.

The numerical increase in ballistic arsenals and launchers is evident in Iran, but also in the DPRK. In 2024, Pyongyang displayed 250 new launchers for its SRBMs.[96] Each launcher can carry four missiles, which would make it possible to launch salvos of missiles over South Korea. Under its current format, combined US and South Korean missile defence could be vulnerable to saturation or defence suppression.[97] With a sufficient force of short-range

[89] *Pavel Podvig, op. cit.*
[90] *Ellen Barry, op. cit.*
[91] *Antoine Bondaz, op. cit.*
[92] *Li Bin, 'The Revival of Nuclear Competition in an Altered Geopolitical Context: A Chinese Perspective',* American Academy of Arts & Sciences, *2020,* https://www.amacad.org/sites/default/files/publication/downloads/Daedalus_Sp20_4_Li.pdf
[93] *The first official references to the reinforcement of the Chinese arsenal appear in the Science of Military Strategy 2013. In 2022, Xi Jinping called on China to build a* 'strong system of strategic deterrence'. *(练兵备战，打造强大战略威慑力量体系，为民族复兴保驾护航打造强大的),* Sohu (**搜狐**), *25 October 2022. The Science of Military Strategy is translated by the China Aerospace Studies Institute,* https://www.airuniversity.af.edu/Portals/10/CASI/documents/Translations/2021-02-08%20Chinese%20Military%20Thoughts-%20In%20their%20own%20words%20Science%20of%20Military%20Strategy%202013.pdf?ver=NxAWg4BPw_NylEjxaha8Aw%3d%3d
[94] *Matthew R. Costlow, 'The Missile Defense "Arms Race" Myth',* Strategic Studies Quarterly - Policy Forum, *Spring 2021,* https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-15_Issue-1/Costlow.pdf
[95] *David J. Trachtenberg, Michaela Dodge, and Keith B. Payne, 'The "Action-Reaction" Arms Race: Narrative vs. Historical Realities',* Occasional Paper, *vol. 1, no. 6, NIPP, June 2021,* https://nipp.org/wp-content/uploads/2021/06/OP-6-final.pdf
[96] *Zuzanna Gwadera, 'North Korea Doubles Down on Short-Range Ballistic-Missile Production',* Missile Dialogue Initiative, *IISS, 27 August 2024,* https://www.iiss.org/online-analysis/missile-dialogue-initiative/2024/08/north-korea-doubles-down-on-short-range-ballistic-missile-production/
[97] *Stéphane Delory, Antoine Bondaz, Christian Maire, and GEO4i, 'North Korean Short Range Systems: Military*

missiles (KN-23, KN-24, and KN-25), and if Pyongyang were able to protect its launchers from pre-emptive destruction, several strike options could be envisaged by the DPRK.

Defence also creates a dynamic arms race on the operational level, as shown in Ukraine. To overcome defence, it has proved advantageous to organise saturation with alternative and complementary means of delivery. In particular, cheap UAVs such as the Shahed-136, whose price tag can be as low as $35,000, are used in addition to other strike systems and play a decisive role in a saturation strategy.[98] This has been displayed since 2022 by Russia in its strike campaigns against Ukraine.

	Cost per unit ($)	Hit percentage	Cost per target struck ($)
Shahed drone	35,000	10	353,535
Kh-59	500,000	29	1,748,252
Kh-22	1,000,000	95	1,057,082
Iskander-K	1,000,000	36	2,747,253
Kalibr	1,000,000	20	4,926,108
S-300/S-400	1,500,000	100	1,507,538
Iskander-M	2,000,000	90	2,224,694
Kh-47 Kinzhal	15,000,000	74	20,161,290

Figure 12: Cost-effectiveness of selected Russian weapons (Source: CSIS)

The attacks carried out by Russia against Ukraine combine—often to varying degrees—Shahed drones, cruise missiles of various types and speeds, and ballistic or quasi-ballistic missiles. Shahed drones, although intercepted in their overwhelming majority, are used to disorient the defence and to saturate and divert detection and warning capabilities. The effect of degradation or even destruction seems to be generally sought through ballistic or cruise missiles.

One of the major effects of these strike campaigns is undoubtedly the suppression of anti-aircraft and anti-missile defences through the depletion of interception missile resources. This suppression effect has been achieved by Russian strikes in Ukraine, which have depleted many Soviet-era missile stocks, creating gaps in multi-layered coverage and ultimately limiting the number of sites that can be defended. Western deliveries, while providing new capabilities, cannot quantitatively compensate for this erosion in several segments. The quantity of missiles is not the only issue: the number of weapons systems (radars, launchers, C2) is also known to be insufficient. Ultimately, Kyiv is currently only able to cover 25% of its needs.[99]

HOPING TO DEFEAT: QUALITATIVE RESPONSE

If the deployment of defences has an effect on quantitative development, it also leads to qualitative efforts. On the Russian side, US announcements regarding missile defence are regularly echoed by public speeches in Moscow detailing the type of countermeasures envisaged, including enhanced missile defence penetration capabilities; strike capabilities aimed at the destruction of missile defence assets; and active and passive defences for national strategic assets, including NC3 and strategic nuclear delivery systems.[100] In 2018, Vladimir Putin spoke '*about the newest systems of Russian strategic weapons that we are creating in response to the unilateral withdrawal of the United States of America from the Anti-Ballistic Missile Treaty*' and announced that '*during all these years since the unilateral US withdrawal from the ABM Treaty, we have been working intensively on advanced equipment and arms, which allowed us to make a breakthrough in developing new models of strategic weapons.*'[101]

Overcoming defence through technological advancement is an objective that can lead to two combined measures: improving warhead penetrability and diversifying the means of delivery.

Improvement of warhead penetrability

In addition to number, a first countermeasure to missile defence is adaptation and modernisation of warheads to increase penetration. Modernising and adapting warheads and delivery vehicles has been regularly undertaken with this in mind since the Cold War. In particular, states have developed penetration aids, which may be components added to the re-entry vehicle or tactics to decrease its vulnerability. These can have several objectives which are not

Consequences of the Development of the KN-23, KN-24 and KN-25', HCoC In-Depth Report, *FRS*, https://www.nonproliferation.eu/hcoc/north-korean-short-range-systems/

[98] *Neil Hollenbeck, Muhammed Hamza Altaf, Faith Avila, Javier Ramirez, Anurag Sharma, and Benjamin Jensen, 'Calculating the Cost-Effectiveness of Russia's Drone Strikes', CSIS, 19 February 2025,* https://www.csis.org/analysis/calculating-cost-effectiveness-russias-drone-strikes

[99] *Hugo Lowell, 'US Only Has 25% of All Patriot Missile Interceptors Needed for Pentagon's Military Plans',* The Guardian, *8 July 2025,* https://www.theguardian.com/us-news/2025/jul/08/us-pentagon-military-plans-patriot-missile-interceptor

[100] *See in particular Dmitry Medvedev, 'Statement in Connection with the Situation Concerning the NATO Countries' Missile Defence System in Europe', Kremlin.ru, 23 November 2011,* http://en.kremlin.ru/events/president/news/13637

[101] *Vladimir Putin, op. cit.*

mutually exclusive. First, they can aim at saturating defences by multiplying the number of targets that an interceptor needs to engage, for instance by adopting MIRVs. The second possibility is concealment, which reduces the vulnerability of the re-entry vehicle to radar detection. One way of doing this is through stealth, or through various jamming techniques against detectors. Missiles and warheads can attempt to evade defences by manoeuvring through them in the atmosphere (quasi-ballistic missiles, hypersonic missiles) thanks to aerodynamic controls but also through exo-atmospheric manoeuvres of the warhead. This technology is still in development, although Russian missiles are rumoured to be using it.[102] Russia's Iskander-M are reportedly also using random number generation to evade defence in the terminal phase.[103]

All countries deploying missile arsenals are potentially interested in these various techniques and are trying to upgrade their delivery vehicles to make them more sophisticated and resilient to defence. For instance, Iran has started to deploy missiles with manoeuvring warheads (MARVs), such as the Shahid Haj Qassem or the Emad.[104] MARVs are more difficult to intercept by terminal endo-atmospheric defence but do not prevent exo-atmospheric interception if penetration aids are not deployed.

In 2024, the DPRK tested a modified IRBM or ICBM able to carry multiple warheads as well as decoys, according to the authorities.[105] According to the UN Panel of Experts on North Korea, Pyongyang was trying to further miniaturise its nuclear warheads in order to incorporate penetration aid packages.[106]

The United States, Russia, and China are generally counting on sophisticated penetration aids and stealth coating to optimise penetration. Exo-atmospheric manoeuvres have been described in academic articles, notably in China, but little information is available to assess their existence.

Diversification of means of delivery

Missile defence architectures are developed and optimised for certain threats. This means that they may be configured to intercept delivery vehicles that follow a certain trajectory, or come from a certain direction, at a certain speed. One way of overcoming these defences is to present them with alternative strike systems against which they are less effective.

Three of these types of technological developments are emblematic of this trend. At the theatre level, North Korea faces the reinforcement of defensive capacities on the peninsula and the integration of US, South Korean, and Japanese detection means, which is a particular concern for its short-range ballistic arsenal due to the short flight time and the impossibility of using penetration aids. This is probably one of the reasons behind Pyongyang's choice to turn towards quasi-ballistic missiles. These systems have thus far been developed with success by the United States (MGM-140 ATACMS) and the Soviet Union/Russia (SS-21 and SS-26 Iskander-M). Their trajectory remains totally within the atmosphere, and they are able to manoeuvre during their flight, which makes them harder to intercept, even if their accuracy may be reduced. One of the particularities of quasi-ballistic missiles is that they can add a skipping manoeuvre to extend their range and change the direction of their trajectory. Because the whole trajectory remains within the atmosphere, a quasi-ballistic missile is, in theory, able to modify its attitude on most of its trajectory through the use of aerodynamic control surfaces. Moreover, since the defender cannot know if the missile will skip or not, the interception can be rather complex.[107] All these manoeuvres are, however, conducted at the expense of the missile's speed and may expose it to terminal defence. It cannot be ruled out that the interception of Kinzhal in Ukraine has been facilitated by their low terminal speed.

There is a high probability that US work on missile defence, as early as the late 1980s and the 1990s, was influential in North Korean technological decisions, since the effort to develop quasi-ballistic

[102] *Richard Speier, 'Missile Nonproliferation and Missile Defense: Fitting Them Together',* Arms Control Today, *November 2007,* https://www.armscontrol.org/act/2007-11/features/missile-nonproliferation-and-missile-defense-fitting-them-together

[103] *Seth Hosford, 'Russia Goes Random: Iskander-M's Ballistic Missile Defense Evasion',* Arms Control Wonk, *13 August 2025,* https://www.armscontrolwonk.com/archive/1220703/russia-goes-random-iskander-ms-ballistic-missile-defense-evasion/

[104] *Behnam Ben Taleblu and James D. Syring, 'Assessing the Islamic Republic of Iran's Ballistic Missile Program',* FDD, *15 February 2023,* https://www.fdd.org/analysis/2023/02/15/arsenal-assessing-the-islamic-republic-of-irans-ballistic-missile-program/

[105] *Thomas Newdick, 'Conflicting Claims Surround North Korea's Test Of Multiple Independently Targetable Reentry Vehicle',* The War Zone, *27 June 2024,* https://www.twz.com/news-features/conflicting-claims-surround-north-koreas-supposed-test-of-multiple-independently-targetable-reentry-vehicle

[106] *Report of the Panel of Experts established pursuant to resolution 1874 (2009), S/2020/840, UN Security Council, 28 August 2020,* https://www.securitycouncilreport.org/atf/cf/%7B65BFCF9B-6D27-4E9C-8CD3-CF6E4FF96FF9%7D/s_2020_840.pdf

[107] *Stéphane Delory, Antoine Bondaz, Christian Maire, and GEO4i, op. cit.*

technologies can be traced back to this period. In the process, Pyongyang acquired key components and technologies that not only made it more proficient and able to develop its own deterrence, but also put it in a position to export these new systems, as has been seen with the export of the KN-23 and KN-24 to Russia and their use against Ukraine since 2023.[108]

A second example is the focus on hypersonic glide vehicles, especially in Russia, as a way to escape strategic defence and its potential impact on stability. The Avangard hypersonic glider project was launched in the 1980s (Albatross project). It was part of the 'asymmetric response' strategy devised by Soviet strategists following the announcement of the SDI, the essence of which was to deter the United States from pursuing the development of a global missile defence system by creating weapons capable of circumventing it before it was even built.[109] It was revived following the United States' decision to withdraw from the ABM Treaty.

Russian experts and officials have insisted on the superiority of hypersonic gliders over defence. First, '*the trajectory of a glider warhead passes lower than the minimum height at which all possible exo-atmospheric interceptor missiles can operate*.' Second, some note that it is '*practically an invulnerable target to airborne laser missile defence weapons*', while others focus on the trajectory: '*while moving toward its target, a glider is capable of manoeuvring both laterally by several thousand kilometres and vertically. This enables it to bypass missile defence systems' intercept zones by overflying or ducking under them. Even entering an area protected by missile defence systems while approaching the target, the glider would confidently overpower missile defences due to its higher velocity compared to an interceptor and due to its unpredictable trajectory*.'[110]

According to some, the Avangard could be primarily intended to destroy or disrupt enemy missile defences in order to facilitate a retaliatory nuclear strike by other means available to Russian strategic nuclear forces.[111] In 2018, Putin concluded: '*We started to develop new types of strategic arms that do not use ballistic trajectories at all when moving toward a target and, therefore, missile defence systems are useless against them, absolutely pointless*.'[112] This assertion is far from certain, as the massive deployment of space sensors enables better tracking of the glider, which, during the glide, will have sequential predictive trajectories. Moreover, the glider is blind and will manoeuvre according to a previous estimate of the defence. By contrast, defence is not blind and can be layered to optimise interception on different segments of the trajectory. While interception remains a challenge on short trajectories because of the limited duration of the flight, the deployment of defence along the penetrating path of the glider may prove challenging for the offence. Currently difficult to imagine, notably because interceptors' means of propulsion have to be adapted to these new threats, this kind of defence may not be unfeasible in the long term.

Another option is the use of a Fractional Orbital Bombardment System (FOBS), developed by the Soviet Union in the 1960s and ultimately banned by arms control agreements between the United States and the USSR.

On 16 October 2021, the *Financial Times* reported that China had conducted a test of a fractional orbital bombardment system in the summer of 2021. According to US sources cited in the article, the test involved the use of a Long March 2C rocket that propelled a hypersonic glider capable of carrying a nuclear warhead into orbit. The flight reportedly completed a partial revolution around the Earth in low orbit before deorbiting and landing 32 km from the target.[113] A second test of the system is said to have taken place on 13 August 2021, but the journalists did not specify which vehicle was used for this second test.[114]

The Chinese authorities have denied any weapons testing, stating that the flight in question was that of a reusable space shuttle.[115] However, other media sources have supported the theory that one or two

[108] *Justin McCurry, 'From Ammunition to Ballistic Missiles: How North Korea Arms Russia in the Ukraine War',* The Guardian, *25 April 2025,* https://www.theguardian.com/world/2025/apr/25/how-north-korea-arms-russia-in-ukraine-war
[109] *Sergey Oznobishchev, Vassily Skokov, and Vsevolod Potapov,* ***Как готовился «Асимметричный ответ» на «Стратегическую оборонную инициативу Р.Рейгана'*** *[How the 'asymmetric response' to Reagan's Strategic Defense Initiative was prepared], Ruskline.ru, 14 August 2021,* https://ruskline.ru/analitika/2012/08/14/kak_gotovilsya_assimetrichnyj_otvet_na_strategicheskuyu_oboronnuyu_iniciativu_rrejgana/
[110] *'U.S. Missile Defense Systems Cannot Counter Russia's Avangard System – Russian Defense Ministry Experts',* Interfax, *1 February 2019.*
[111] *The yield of the warhead (possibly 2 Mt) induces, more probably, a countervalue mission.* *Michael Kofman, 'Beyond the Hype of Russia's Hypersonic Weapons',* The Moscow Times, *15 January 2020,* https://www.themoscowtimes.com/2020/01/15/russias-hypersonic-weapons-a68907
[112] *Vladimir Putin, op. cit.*
[113] *Demetri Sevastopulo and Kathrin Hille, 'China Tests New Space Capability with Hypersonic Missile',* Financial Times, *16 October 2021,* https://www.ft.com/content/ba0a3cde-719b-4040-93cb-a486e1f843fb
[114] *Demetri Sevastopulo, 'China Conducted Two Hypersonic Weapons Tests This Summer',* Financial Times, *20 October 2021,* https://www.ft.com/content/c7139a23-1271-43ae-975b-9b632330130b
[115] *'Foreign Ministry Spokesperson Zhao Lijian's Regular Press Conference on October 18, 2021', Ministry of*

FOBS were fired in the summer.[116] In November, Lieutenant General Saltzman, deputy chief of operations for the United States Space Force, confirmed the FOBS theory, highlighting China's use of advanced technologies. Particular attention was drawn to the capabilities of the hypersonic glider.[117]

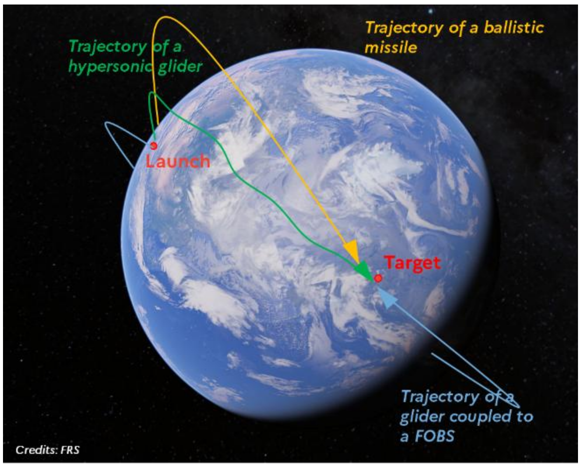


Figure 13: Comparison between FOBS and other delivery vehicles' theoretical trajectories (Credit: FRS)

As was the case with Soviet FOBS projects, the circumvention of US defences may explain China's interest in this system, with American defence infrastructure continuing to be largely oriented towards the north and offering less detection and interception capability in the southern hemisphere (areas where the system could be deorbited).[118] The US radar detection architecture currently relies on five radars belonging to the Upgraded Early Warning Radars system, deployed in California, Alaska, Massachusetts, Greenland, and the United Kingdom.[119] The deployment of space sensors nullifies the argument of ground radar circumvention, as China has most probably anticipated. Nonetheless, a FOBS coupled with a glider remains useful, as it diverts the penetration trajectories of offensive weapons systems. Moreover, the very high velocity of the glider, combined with its altitude, exerts tremendous stress on defence. Coupled with a high-yield warhead, such a weapon could prove rather dissuasive.

MISSILE DEFENCE AND SPACE

Despite the space dimension of the SDI, which led to it being dubbed 'Star Wars', missile defence has so far relied largely on ground infrastructure. Ground-based radars have been deployed, and most interceptors are either deployed on ships or on ground launchers. However, future endeavours will have a stronger space dimension, leading to the increased militarisation of space.

Militarisation of space

The Trump administration's 'Golden Dome' project is the later iteration of a concept that relies doubly on space.

First, through the PWSA, space assets will largely be responsible for detection but also tracking. With this programme, the United States aims at deploying between 300 and 500 satellites serving military purposes, enabling it to improve targeting, command and control, but also in-flight interception. It will include a constellation dedicated to detecting and tracking ballistic and hypersonic objects (Hypersonic and Ballistic Tracking Space Sensor) deployed by the Missile Defense Agency and complemented by similar satellites operated by the Space Defense Agency, as well as intelligence, surveillance, and reconnaissance (ISR) constellations enabling the identification of strategic, fixed, and mobile targets.

Also, the PWSA will be one of the main vehicles enabling US missile defence to take on a global dimension, by connecting each sensor and weapon, whether tactical or strategic, to other regional or strategic sensors. It will also enable data from these sensors to be merged and redistributed so that it can be used in both defensive and offensive missions. But the development of the PWSA, which will in all likelihood be replicated by China and possibly other actors, transforms space into a 'mega' military enabler for nearly all military operations, decoupling their speed, the depth, and their effects in such a way

Foreign Affairs, China, 18 October 2021, https://www.mfa.gov.cn/eng/xw/fyrbt/lxjzh/202405/t20240530_11347141.html

[116] *Michael R. Gordon, 'China Tests Hypersonic Missile in Military Expansion',* The Wall Street Journal, *20 October 2021,* https://www.wsj.com/politics/national-security/china-tests-hypersonic-missile-in-military-expansion-11634744351; *James J. Cameron, 'What Did China Test in Space, Exactly, and Why?',* The Washington Post, *21 October 2021,* https://www.washingtonpost.com/politics/2021/10/21/what-did-china-test-space-exactly-why/

[117] *Theresa Hitchens, 'It's a FOBS, Space Force's Saltzman Confirms Amid Chinese Weapons Test Confusion',* DefenseNews, *29 November 2021,* https://breakingdefense.com/2021/11/its-a-fobs-space-forces-saltzman-confirms-amid-chinese-weapons-test-confusion/

[118] *Ankit Panda, Twitter, 18 October 2021,* https://x.com/nktpnd/status/1450109684082528262

[119] *'Upgraded Early Warning Radars (UEWR)', MDAA, December 2018,* https://missiledefenseadvocacy.org/defense-systems/upgraded-early-warning-radars-uewr/

that acquiring space dominance is becoming the key to victory. In that sense, the interaction between missile defence and missile offence is closely intertwined with space operations. Their respective destabilising effects are combined and cannot be treated separately.

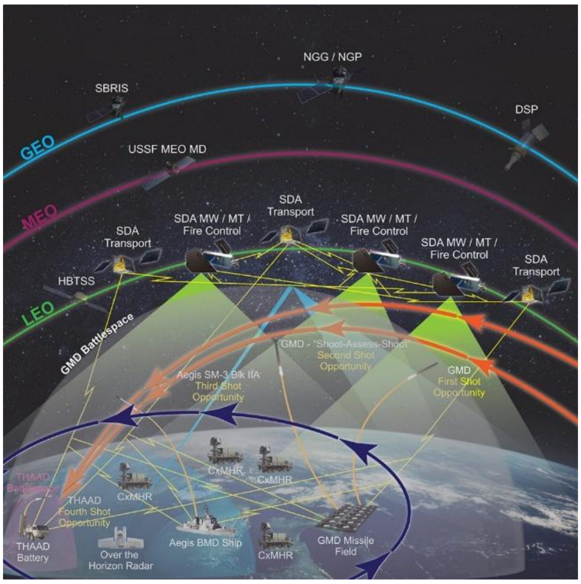


Figure 14: Visualisation of possible Golden Dome architecture, proposed by Leonardo DRS (Credit: Leonardodrs.com)

As was the case for the SDI, space interceptors are planned to be deployed in Golden Dome. It is likely that these will mostly take the form of non-kinetic systems, for technical reasons,[120] and they are supposed to remain defensive weapons by nature. Nonetheless, this development will be perceived as one of the first actual deployments of weapons in space. In response, Russia and China may pursue their investments in weapons such as already-existing kinetic direct-ascent anti-satellite (ASAT) weapons and orbital kinetic and non-kinetic objects to destroy the US architecture. Whether or not this is actually considered by Washington, its adversaries will assume that its space-deployed systems can have offensive purposes. It is more than likely that the utility of these space-based non-kinetic (or even kinetic) systems is already perceived as going beyond simple interception and applying to the destruction of other space vehicles.[121]

In theory, Golden Dome will enable the United States to rapidly accelerate the development of counter-space capabilities that can be seen as an alternative means of restoring a certain strategic dominance. Non-kinetic systems could enable destructive actions without creating debris, offering a solution to various issues related to offensive space operations.[122] Unfortunately, the renewed debate on nuclear weapons in space, the local effects of persistent radiation on an orbit, or the use of debris to pollute low orbits, mainly used by the PWSA, highlights that space operations are also linked to nuclear operations. Neutralising orbits in order to thwart a nuclear attack could be seen by some actors as a rational choice, despite its consequences. More broadly, the deployment of megaconstellations, considered to be generally immune to counter-space operations because of the high number of assets in orbit, may lead to the development of mass destruction devices to neutralise them.

Given US, but also Chinese and Russian interest in space as an operational domain, anti-missile and counter-space assets are bound to remain interlinked. However, the weaponisation of space is a global trend to which missile defence contributes, but for which it is not fully responsible. As such, major powers feel too many incentives to invest in this weaponry to change their decisions to deploy weapons in space, regardless of what is happening in the anti-missile domain.

Interceptors and ASAT weapons

Another source of concern regarding space security is linked to the proximity between anti-missile interceptors and ASAT weapons. Both aim at intercepting objects outside of the atmosphere and moving at high speed.[123] This was illustrated for instance in February 2008 when Washington decided to shoot down a deorbiting satellite with a modified SM-3 interceptor.[124]

As it is, several weapons have been officially presented as serving missile defence purposes but were subsequently tested in debris-creating operations against satellites.

Chinese systems have in particular maintained some ambiguity. The early tests of the DN-1 and DN-2, conducted in 2010 and 2013, may have been designed against satellites, but also to develop the subsequent DN-3, which seems to be conceived as a missile interceptor.[125] This led analysts to consider that the missile defence programme could serve to disguise advances on ASAT weapon development, or to avoid the controversy associated with testing ASAT systems.[126] On 23 July 2014, China announced

[120] *Stéphane Delory, op. cit.*
[121] *Ibid.*
[122] *Ibid.*
[123] *Jacob Mezey, op. cit.*
[124] *Dwayne A. Day, 'Burning Frost, the View from the Ground: Shooting Down a Spy Satellite in 2008',* The Space Review*, 21 June 2021,* https://www.thespacereview.com/article/4198/1
[125] *Jacob Mezey, op. cit.*
[126] *Bruce W. MacDonald and Charles D. Ferguson, 'Understanding the Dragon Shield: Likelihood and Implications of Chinese Strategic Ballistic Missile Defense',* FAS*, 30 September 2015,*

that it had conducted a '*land-based missile interception test*', but '*the United States has high confidence in its assessment, that the event was indeed an ASAT test*.'[127] The Chinese government therefore seems to want to capitalise on developing technologies that can serve both purposes, even if in its eyes the space element appears to have priority.[128]

In Russia, the PL-19 Nudol anti-satellite weapon was initially designed to be an exo-atmospheric interceptor meant to replace the nuclear-tipped Gorgon.[129] For countries such as India, developing and testing direct-ascent ASAT weapons has also served as a way to improve missile defence technologies, in particular to improve and test hit-and-kill capabilities. In the Indian case, the ASAT programme has been perceived as a potential technology demonstrator for its indigenous missile defence developments.[130]

More generally, the modernisation of interceptors has increased the confusion between them and ASAT weapons, with the S-500 for instance being described as fitted for low-orbit interception. The conversion of an old SM-3 Block IB into an ASAT weapon in 2007 essentially required software adaptations. Low orbits are very exposed to ASAT operations, and even medium and high orbits cannot be considered safe, as China mimicked a geostationary interception in 2013.[131]

https://uploads.fas.org/2015/09/DragonShieldreport_FINAL.pdf

[127] *Frank A. Rose, 'Ballistic Missile Defense and Strategic Stability in East Asia', Remarks,* FAS*, Washington, D.C., 20 February 2015,* https://2009-2017.state.gov/t/avc/rls/2015/237746.htm

[128] *Bruce W. MacDonald and Charles D. Ferguson, op. cit.*

[129] *Christian Maire, 'La place de l'ASAT à ascension directe dans la posture de dissuasion stratégique russe',* Note de la FRS*, N°41/2022, FRS, 15 December 2022,* https://www.frstrategie.org/publications/notes/place-asat-ascension-directe-dans-posture-dissuasion-strategique-russe-2022

[130] *Victoria Samson, 'India's Missile Defense/Anti-Satellite Nexus',* The Space Review*, 10 May 2010,* https://www.thespacereview.com/article/1621/1

[131] *Zachary Keck, 'China Secretly Tested an Anti-Satellite Missile',* The Diplomat*, 19 March 2014,* https://thediplomat.com/2014/03/china-secretly-tested-an-anti-satellite-missile/

ARMS CONTROL AND NON-PROLIFERATION

NEGOTIATING RESTRAINTS ON OFFENCE AND DEFENCE?

Rationale for offence/defence constraints

Since the US withdrawal from the ABM Treaty, questions have been raised about the possibility of re-imposing limitations on defensive systems. On the Russian side, there is a clear argument for re-linking strategic offensive forces and defensive capacities, on the model of the SALT I/ABM Treaty.[132] As Washington has abandoned the narrative that missile defence is only tailored against proliferating countries, it might be strategically sound to consider negotiations on offence and defence with major competitors, namely China and Russia.[133] On the one hand, one of the avowed purposes of US homeland missile defence is to counter the modernisation and growth of these two countries' nuclear forces. On the other, Beijing and Moscow complain that they are compelled to develop their arsenals quantitatively and qualitatively to take into consideration missile defence. It could therefore be advantageous for all to consider restrictions in both segments, in order to avoid the escalation of an arms race.[134]

Barriers to progress on arms control

Nonetheless, three factors complicate the re-integration of missile defence into strategic arms control. First, the system conceived by Washington is now a fully integrated architecture, which does not clearly distinguish between what serves strategic or tactical purposes. The aim of the PWSA is precisely to communicate data from different layers and to enable the best-positioned interceptors to engage the threatening weapons. It would therefore be increasingly difficult to decide on which systems arms control limitations should be applied. Technically, limits imposed by the ABM Treaty on speed, testing, and deployment would be very difficult to replicate, as theatre systems, used to intercept non-strategic threats, are now within the boundaries of or beyond these limits. The reduction in the size of the missiles and their radars, the deployment of naval components, and the rise of space sensors would pose nearly insurmountable hurdles to defining what can and cannot be deployed, where and how it is stationed, and in what numbers. Moreover, the issue has a strong political sensitivity in Washington and has become somehow non-negotiable in the eyes of the Republican Party. It is hard at this stage to imagine there being any political will to part with capacities that have been proclaimed as paramount for national security and led to major investments.

Second, imposing constraints on missile defence as part of bilateral or trilateral strategic arms control seems less relevant in a context of multipolarity. Other actors should be taken into account, such as India, for instance, in the Indo-Pacific, or NATO countries.

Last, the main purpose of most current missile defence is above all the interception of conventional threats. It is not directly linked to strategic arms, even if more and more future weapons systems will have a strategic capability. The German Arrow 3 is a typical example of the emergence of a strategic capability in the framework of conventional deterrence. Indeed, any agreement on missile defence should entail a similar agreement on offensive conventional capabilities. With current developments, it would be politically difficult to secure the ability to intercept conventional devices but forego the option of intercepting nuclear ones, since, in both cases, missile defence is a decisive factor in the proliferation of offensive weapons systems.

CONSEQUENCES FOR NON-PROLIFERATION INSTRUMENTS

The development and refinement of missile defence has not curbed the will to acquire ballistic missiles in many regions of the world. Few instruments exist at the global level to prevent the proliferation of missiles, and those that do exist, such as the MTCR,

[132] *Alexey Arbatov, 'A New Era of Arms Control: Myths, Realities and Options'*, Carnegie Moscow Center, *24 October 2019,* https://carnegie.ru/commentary/80172
[133] *Tytti Erästö and Matt Korda, 'Time to Factor Missile Defence into Nuclear Arms Control Talks'*, SIPRI, *30 September 2021,* https://www.sipri.org/commentary/topical-backgrounder/2021/time-factor-missile-defence-nuclear-arms-control-talks
[134] *Pranay R. Vaddi and John K. Warden, 'Golden Dome and Arms Control: Impediment or Opportunity?',* Bulletin of the Atomic Scientists*, vol. 81, no. 4, 2025, pp. 296–304.*

are restricted to WMD-capable delivery vehicles. In 2002, the White House claimed that '*the MTCR and missile defenses play complementary roles in countering the global missile threat*.'[135] Today, the development of missile defences seems to be both addressing the deficiencies of international regulations on missile proliferation and one of the many challenges facing this regime.

Incentives to acquire or develop missiles

In the early 2000s, US officials and experts hoped that robust defences could dissuade countries from developing a ballistic arsenal. Thus, former official Richard Speier wrote: '*If missile defense is likely to work [...] it makes it less attractive to get in the business of developing missiles in the first place, very much complementing the efforts of the MTCR to stop development. [...] So, they really can complement each other*.'[136] However, in the regions where anti-missile systems have been deployed, ballistic missile acquisition continues to be perceived as attractive. The Middle East is an interesting case. Bahrain, Saudi Arabia, Qatar, and the UAE have all bought both offensive and defensive missile systems. Coming up against the most developed and effective missile defence in the world has not led Iran to reconsider developing a massive missile arsenal as a conventional deterrent. Tehran believes that a mix of countermeasures (dissimulation, saturation, and the use of different categories of weapons) would be enough to preserve an edge for the offensive side. It will be interesting to see if the three episodes of April 2024, October 2024, and June 2025 provoke a change of view in Iran. On the one hand, Israel's missile defence but also its physical destruction of launchers prior to use has clearly shown its superiority against the systems owned and developed by Iran. Nonetheless, reports that not only Israel but also US regional capacities may have seen their stockpiles of interceptors seriously depleted after the twelve days of conflict in 2025 may fuel the narrative that a prolonged missile strike campaign can eventually exhaust missile defence systems. Moreover, so much investment has been made in the programme that it may be difficult to abandon it for something new, except in the case of more effective weapons systems such as hypersonic.

In East Asia, the United States, Japan, and South Korea have also invested considerably in defensive capacities. Pyongyang has reacted to these developments by strengthening, modernising, and diversifying its missile arsenal, which is clearly aimed at the delivery of WMDs and in particular nuclear warheads.

Besides, the effectiveness of missile defence raises the question of the choice of ammunitions. As such, missiles are a rather ineffective weapon for the destruction of infrastructure and populations, as their limited payload requires them to be used in mass. If only a few warheads reach their target, the effect of the warhead is of prime importance. The use of thermobaric and fuel–air devices is clearly a possible solution, but the more effective way of restoring an advantage is naturally through the use of WMDs. In the end, missile defence and WMD proliferation therefore remain linked.

Effects on export control regimes

There are many factors explaining the challenges facing missile proliferation and export control regimes such as the MTCR. Missile defence has however several direct effects on efforts to control the spread of missile technologies.

First, the Bush administration announced in 2002 that '*the United States intends to implement the MTCR in a manner that does not impede missile defense cooperation with friends and allies*.'[137] In practice, some missile defence systems, such as the Patriot, involve missiles for which there is no presumption of denial according to the MTCR.[138] However, this is not the case of the SM-3 or the Arrow 2 and 3. In the context of Golden Dome, it is still argued that strategic trade restrictions should be applied with leniency if it can allow US partners to more easily acquire ballistic missile defence components.[139] By considering that, because of their defensive nature, these systems should not be treated as other missiles of their classes, exporters are creating loopholes in export control mechanisms. It has indeed been shown that interceptors could be used as offensive

[135] *George W. Bush, National Security Presidential Directive 23, The White House, 16 December 2002,* https://irp.fas.org/offdocs/nspd/nspd-23.htm#:~:text=This%20law%20states%2C%20%22It%20is,deliberate)%20with%20funding%20subject%20to
[136] *Richard Speier, 'Complementary or Competitive? Missile Controls vs. Missile Defense',* Arms Control Today, *June 2004,* https://www.armscontrol.org/act/2004-06/features/complementary-or-competitive-missile-controls-vs-missile-defense
[137] *George W. Bush, op. cit.*

[138] *Mitch Kugler, 'International Missile Defense Cooperation and the MTCR',* Nonproliferation Policy Education Center, *30 June 2003,* https://npolicy.org/international-missile-defense-cooperation-and-the-mtcr/
[139] *Ola Craft, 'Revising Missile Controls Is Necessary to Help Allies and Prevent New Nuclear States',* Lowenstein Sandler, *5 May 2025,* https://www.lowenstein.com/news-insights/publications/articles/revising-missile-controls-is-necessary-to-help-allies-and-prevent-new-nuclear-states

weapons (use of the S-300 for land attacks in Ukraine), and their technology can be retrofitted for offensive systems.[140]

Second, the goal of countering or defeating defences leads proliferating countries to seek penetration aids. Deploying these different tools may necessitate foreign assistance or the acquisition of foreign components, including dual-use items. Export controls may be used to limit the sophistication of missiles by restricting access to certain components. Some of these subsystems may already be controlled in the MTCR. For instance, under MTCR Category I, Item 2.A.1.b of the Annex List refers to re-entry vehicles and could be interpreted as covering penetration aids contained in them. In Category II, Item 17.A.1 covers stealth technology as well as nuclear effects protection. However, there have been proposals to make the inclusion of penetration aids in MTCR-controlled items more explicit, in order to limit the spread of these technologies. In particular, a RAND report of 2014 suggests adding the following as new Category I items: 'complete, integrated countermeasure subsystems; complete subsystems for missile defense test targets; and boost-glide vehicles'; as well as a number of subsystems in Category II: 'canisters and dispensers; post-boost subsystems; replicas and decoys; electronic countermeasures; chaff, obscurants, and flares; reentry vehicle or decoy signature control mechanisms; plume signature control mechanisms; wake modification mechanisms; maneuvering subsystems; and submunitions'.[141] RAND subsequently made similar recommendations regarding cruise missiles.[142]

MISSILE DEFENCE AND ARMS CONTROL IN SPACE?

Absence of formal arms control

With regard to the weaponisation of space, the Outer Space Treaty only prohibits the placement in space of WMDs. As such, with regard to missile defence, signatory states are simply banned from placing potential nuclear interceptors in orbit.[143]

In 1981, two United Nations General Assembly (UNGA) resolutions addressed this issue. A/RES/36/97, introduced by the Western Europe and Others Group, recommended the negotiation within the Conference on Disarmament (CD) of 'an effective and verifiable agreement to prohibit anti-satellite systems'.[144] A/RES/36/99, sponsored by the Eastern European and Other States Group, preferred a broader approach and encouraged the adoption of a treaty prohibiting the stationing of weapons of any kind in outer space.[145] Within the CD, the 'Prevention of an Arms Race in Outer Space' has been an agenda item since 1982, and since then, a number of proposals have been put forward to expand the scope of international space law in this direction. Among the most notable examples is the draft treaty on the Prevention of the Placement of Weapons in Outer Space, the Threat or Use of Force against Outer Space Objects (PPWT), presented by Russia and China in February 2008. This draft treaty received some support in the international community but generally met with resistance, in particular because it limits its focus to weapons physically located in outer space and does not take into account the possibility of using weapons located on Earth or in its atmosphere against space objects. The question of verification has also been a dividing issue.

For many years, states have therefore tried and failed to create international space regulation that would prevent the weaponisation of space. A majority of countries still hopes to be able to deal with this issue through arms control and non-proliferation. Thus, in December 2022, the UNGA adopted a resolution creating a Group of Governmental Experts (GGE), whose mandate is to 'consider and make recommendations on substantial elements of an international legally binding instrument on the prevention of an arms race in outer space, including, inter alia, on the prevention of the placement of weapons in outer space'.[146] The final report of the GGE, presented in September 2024, prudently referred to the prohibition of placing weapons in space: '*A possible element [of a legally or non-legally binding negotiated agreement] could include*

[140] *Richard Speier, op. cit.*
[141] *Richard H. Speier, K. Scott McMahon, and George Nacouzi, 'Penaid Nonproliferation: Hindering the Spread of Countermeasures Against Ballistic Missile Defenses',* RAND, *26 February 2014,* https://www.rand.org/pubs/research_reports/RR378.html
[142] *Richard H. Speier, George Nacouzi, K. Scott McMahon, 'Cruise Missile Penaid Nonproliferation: Hindering the Spread of Countermeasures Against Cruise Missile Defenses',* RAND, *20 October 2014,* https://www.rand.org/pubs/research_reports/RR743.html
[143] *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), adopted on 19 December 1966, signed on 27 January 1967, entered into force on 10 October 1967.*
[144] *Prevention of an Arms Race in Outer Space, A/RES/36/97, UNGA, 9 December 1981,* https://digitallibrary.un.org/record/610780?ln=en&v=pdf
[145] *Prevention of an Arms Race in Outer Space: Draft Resolution, A/C.1/37/L.64, 18 November 1982,* https://digitallibrary.un.org/record/37620?ln=en
[146] *'Further Practical Measures for the Prevention of an Arms Race in Outer Space', UNGA Resolution 77/250,* https://www.undocs.org/A/RES/77/250

obligations not to place weapons in outer space, including those designed to attack outer space systems or objects, or Earth-based targets. The Group discussed relevant challenges and possible options associated with defining a weapon in outer space and verifying such obligations.'[147] This statement shows the reservation of some states participating in the GGE.

The US Defense Space Strategy published in 2020 opens by noting that 'space-based capabilities are [...] an indispensable component of U.S. military power', and that '*space is now a distinct warfighting domain*.'[148] While less open about it, other countries rely extensively on space assets for military operations. China, for instance, has developed a number of counterforce capacities, including space-based. According to US information, Beijing is for instance testing in-orbit servicing satellites that could '*forcibly pull [...] out of position' adversary satellites*.'[149] The US government also believes that Russia tested the concept of deploying nuclear weapons in space back in February 2022.[150] In this context, the prospect of countries agreeing on a multilateral arms control agreement on the placement of weapons in outer space seems remote at best.

Good practices and CBMs

To overcome this political challenge, several efforts have aimed at developing best practices and transparency and confidence-building measures that could address the instability posed by these developments. For instance, the European Union proposed a Code of Conduct in 2014, which, despite failing to be adopted, paved the way for initiatives focused on transparency.

This approach is also supported by the United Kingdom, which has recently led international efforts to define responsible behaviours in outer space. This led to the creation of an open-ended working group in 2023. This work is not certain to put a stop to the drive for the militarisation of outer space. However, it may increase space security through the implementation of several types of practical measures.

First, unilateral restraint measures may be adopted by individual countries to indicate their renouncement of some systems, on the model of the unilateral commitment recently taken against the testing of debris-creating ASAT weapons.[151] Similar measures could be taken for weapons placed in space, in particular regarding the issue of debris.

Second, it has been suggested that it would be more efficient in the short run to focus on behaviours than on banning actual objects, due to the lack of agreement on definitions, for instance of 'weapons' in space.[152] With that in mind, the UK government has proposed several actions that should be regarded as unacceptable, e.g., creation of debris, placement of a co-orbital weapon or an electronic warfare satellite next to the national security satellite of another nation, blinding a satellite with loss of sight, intentionally harming the systems of civilian operators such as emergency responders or normal aircraft operations, and taking over manoeuvring control of an active satellite without the consent of its owner. It instead suggests cooperative measures to address threats to space systems and that rendezvous operations should be conducted in an open and transparent manner.[153] This example shows that the ongoing and future militarisation of space linked to missile defence can be accompanied by some measures to limit its most destabilising effects.

Finally, the concept of transparency can address some of the potential insecurity created by the development of missile defence. The most relevant framework for this is the Hague Code of Conduct

[147] *Report of the Group of Governmental Experts on Further Practical Measures for the Prevention of an Arms Race in Outer Space, A/79/364, 20 September 2024,* https://front.un-arm.org/wp-content/uploads/2025/02/n2427137.pdf
[148] *Defense Space Strategy, Department of Defense, 2020,* https://media.defense.gov/2020/Jun/17/2002317391/-1/-1/1/2020_defense_space_strategy_summary.pdf
[149] *Testimony of General B. Chance Saltzman, Chief of Space Operations, United States Space Force, Submitted to the U.S.-China Economic and Security Review Commission, Hearing on China's Ambitions in Space, 3 April 2025,* https://www.uscc.gov/sites/default/files/2025-04/Chance_Saltzman_Testimony.pdf
[150] *Jonas Schneider and Juliana Süß, 'Russian Nuclear Weapons in Space?',* SWP Comment 2025/C 21, *SWP, 15 May 2025,* https://www.swp-berlin.org/10.18449/2025C21/
[151] *See for instance 'Seven Countries Join ASAT Test Ban',* Arms Control Today, *November 2022,* https://www.armscontrol.org/act/2022-11/news-briefs/seven-countries-join-asat-test-ban, *and 'Space - France's Commitment Not to Conduct Destructive Direct-Ascent Anti-Satellite Missile Tests',* France Diplomacy, *29 November 2022,* https://www.diplomatie.gouv.fr/en/french-foreign-policy/security-disarmament-and-non-proliferation/news/2022/article/space-france-s-commitment-not-to-conduct-destructive-direct-ascent-anti
[152] *Rajeswari Pillai Rajagopalan, 'TCBMs for A Sustainable Outer Space', Conference on Disarmament, 2022,* https://documents.unoda.org/wp-content/uploads/2022/03/180607-TCBMs-CD-Raji-Speaker-Notes.pdf
[153] *'UK Working Paper for the UN Open Ended Working Group on Reducing Space Threats Through Norms, Rules and Principles of Responsible Behaviours', May 2022,* https://documents.unoda.org/wp-content/uploads/2022/05/FINAL-space-threats-OEWG-UK-working-paper-FINAL.pdf

against Ballistic Missile Proliferation (HCoC), which was adopted in 2002 and currently has 145 signatory states. Through the Code, subscribing states are currently compelled to declare annually their policy regarding space launchers and ballistic missiles. They are also asked to pre-notify space launches and ballistic missile tests. Finally, they can invite observers to visit their space launch sites. As seen with the example of the PWSA, missile defence requires the placement of many objects in space, and therefore requires regular launches. Transparency on these activities is more pertinent than ever.

However, the HCoC platform could be used by its subscribing states to increase transparency in a meaningful way with regard to missile defence and space security. First, giving indications on what is being put into orbit, alongside the launch notification, could limit misunderstandings and worst-case assessments regarding the weaponisation of space.

Second, states could decide to notify the testing of two additional types of objects in addition to ballistic missiles: missile interceptors and ballistic targets. Targets used for anti-missile tests, such as the Lockheed Martin LV-2, can be basically similar to actual missiles, and their flight paths designed to mimic IRBM or ICBM trajectories.[154] Long-range interceptors such as the NGI also share many technologies with ballistic missiles, including regarding testing practices. For instance, the latest test of the GMD system, on 11 December 2023, took place from Vandenberg Space Force Base and flew in the direction of Hawaii, in a trajectory that shares some similarities with Minuteman III launches.[155] In the current geopolitical environment, formally revising the scope of the HCoC through a consensual decision taken by subscribing states is unrealistic. However, nothing prevents states from going a step further and adopting an expansive interpretation of their notification requirements, leading them to increase transparency on these two classes of objects.

[154] *'Lockheed Martin Launches LV-2 Target For Ground-Based Midcourse Defense Test', Lockheed Martin, 22 June 2014, https://news.lockheedmartin.com/2014-06-22-Lockheed-Martin-Launches-LV-2-Target-For-Ground-based-Midcourse-Defense-Test*

[155] *Thomas Newdick, 'This Is Exactly How The Latest Ballistic Missile Defense Test Worked',* The War Zone, *13 December 2023, https://www.twz.com/this-is-exactly-how-the-latest-ballistic-missile-defense-test-worked*

CONCLUSION

Missile defence's linkage to missile proliferation is intuitive. There are, however, diverse interpretations of the causal links between the two notions. Missile defence has been developed in part to respond to proliferation. Some of its promoters have even surmised that it would deter proliferation by convincing stakeholders of the futility of developing missile arsenals that could be countered.

However, it has been noted that these developments have also driven missile proliferation, as countries hope to defeat defensive architectures by expanding their missile forces, in number (hope of saturating the defence) or in sophistication (attempt to escape or bypass the defence).

Since 2022, conflicts in Ukraine and the Middle East have led to empirical observations on the use of missile defence, massively mobilised to limit the destruction caused by Russian and Iranian missile strike campaigns.

Initial assessments seem to indicate that number is an important factor, both for missiles, in order to have a military role as a conventional threat and to saturate the defence; and for anti-missile assets. In this regard, the great success of the Israeli systems must be put into perspective with the colossal investment made for decades and the limited size of the territory protected. On the other hand, the constant under-supply of Ukrainian Patriot batteries and the very different geographical reality of Ukraine mean that Russian strikes cause much more casualties and damages in Ukraine.

In Russia, the lessons of the war seem to concern the production and use of strike systems on a mass scale, including cheap drones used to saturate the defence, but also the sophistication of some systems dedicated to precise strikes with a high chance of success. It is too early to know how Tehran will interpret its three consecutive failures to create much damage in Israel through ballistic and drone barrages.

In any case, the appeal of ballistic missiles is bound to persist, and the Trump administration's ambitious 'Golden Dome' programme is merely the most visible aspect of this trend. It is therefore essential to take into consideration the consequences of these developments, in terms of quantitative proliferation and the arms racing phenomenon, the spread of sophisticated technologies, and space security.

Unfortunately, the current context is not propitious to any arms control mechanisms that could address some of the instability linked to missile defence. Non-proliferation regimes, such as the MTCR, can adapt to some of these developments, but they face various challenges. In this context, confidence-building measures could play a role in limiting the most destabilising dimensions, in particular linked to the placement of weapons in space.

Interestingly, the HCoC, as a singular politically binding instrument that addresses both missile proliferation and space security, could be used to increase transparency on key components of missile defence systems, namely interceptors and ballistic targets.

ABOUT THE AUTHORS

STÉPHANE DELORY

Stéphane Delory is a Senior Research Fellow at the Fondation pour la Recherche Stratégique. He conducts research on missile defence and ballistic proliferation.

EMMANUELLE MAITRE

Emmanuelle Maitre is a Senior Research Fellow at the Fondation pour la Recherche Stratégique. She joined the FRS in 2014, focusing mainly on nuclear non-proliferation, disarmament, and deterrence. Emmanuelle holds a master's degree from Sciences Po Paris (Public Affairs).

PREVIOUSLY PULISHED

HCOC RESEARCH PAPERS

Emmanuelle Maitre and Stéphane Delory, 'The Growing Appeal of Missiles: Current Drivers Behind Ballistic Missile Acquisition and Development', *HCoC Research Papers no. 14*, FRS, May 2025.

Christian Maire, 'The Rise of Small Launchers: What Impact on Ballistic Missile Proliferation?', *HCoC Research Papers no. 13*, FRS, April 2024.

Emmanuelle Maitre and Stéphane Delory, 'Hypersonic Missiles: Evolution or Revolution for Missile Non-Proliferation and Arms Control Instruments?', *HCoC Papers no. 12*, FRS, February 2023.

Vann H. van Diepen, 'Origins and Developments of the Hague Code of Conduct', *HCoC Papers no. 11*, FRS, September 2022.

Emmanuelle Maitre and Sophie Brillatz-Moreau, 'The HCoC and Space', *HCoC Papers no. 10*, FRS, March 2022.

Katarzyna Kubiak, 'Harnessing Transparency Potential For Missile Non-Proliferation', *HCoC Papers no. 9*, FRS, December 2021.

Antoine Bondaz, Dan Liu, and Emmanuelle Maitre, 'The HCoC and China: Reluctance and Opportunities to Engage in the Control of Ballistic Missile Exports', *HCoC Papers no. 8*, FRS, September 2021.

Kolja Brockmann, 'Controlling Ballistic Missile Proliferation: Assessing Complementarity Between the HCoC, MTCR and UNSCR 1540', *HCoC Research Paper no. 7*, FRS, June 2020.

Stéphane Delory, 'Ballistic Missiles and Conventional Strike Weapons: Adapting the HCoC to Address the Dissemination of Conventional Ballistic Missiles', *HCoC Research Paper no. 6*, FRS, January 2020.

Stéphane Delory, Emmanuelle Maitre, and Jean Masson, 'Opening HCoC to Cruise Missiles: A Proposal to Overcome Political Hurdles', *HCoC Research Paper no. 5*, FRS, February 2019.

HCOC ISSUE BRIEFS

Emmanuelle Maitre, 'The HCoC and New Technologies', *HCoC Issue Brief no. 16*, January 2025.

Emmanuelle Maitre, 'The HCoC and the Use of Ballistic Missiles in Conflict', *HCoC Issue Brief no. 15*, December 2024.

Emmanuelle Maitre, 'The HCoC and Strategic Risk Reduction', *HCoC Issue Brief no. 14*, May 2023.

Emmanuelle Maitre, 'The HCoC at Twenty', *HCoC Issue Brief no. 13*, November 2022.

Lauriane Héau, 'The HCoC and Northeast Asian States', *HCoC Issue Brief no. 12*, June 2022.

Emmanuelle Maitre and Lauriane Héau, 'The HCoC in the Middle East', *HCoC Issue Brief no. 11*, FRS, March 2022.

Emmanuelle Maitre and Lauriane Héau, 'The HCoC and Southeast Asian States', *HCoC Issue Brief no. 10,* FRS, October 2021.

Emmanuelle Maitre and Sabrina Barré, 'The HCoC and Space', *HCoC Issue Brief no. 9,* FRS, September 2021.

Eloise Watson, 'From Small Arms to WMD Arms Control: Linkages and Shared Benefits', *HCoC Issue Brief no. 8*, FRS, February 2021.

ABOUT THE HAGUE CODE OF CONDUCT

HCoC
SUPPORTING
The Hague Code of Conduct

The objective of the HCoC is to prevent and curb the proliferation of ballistic missile systems capable of delivering weapons of mass destruction and related technologies. Although non-binding, the Code is the only universal instrument addressing this issue today. A multilateral instrument of a political nature, it proposes a set of transparency and confidence-building measures. Subscribing states commit not to proliferate ballistic missiles and to exercise the maximum degree of restraint possible regarding the development, testing, and deployment of these systems.

The Fondation pour la Recherche Stratégique, with the support of the Council of the European Union, has been implementing activities that aim at promoting the implementation of the Code, contributing to its universal subscription, and offering a platform for discussions on how to further enhance multilateral efforts against missile proliferation.

hcoc.at
nonproliferation.eu/hcoc/

This project is funded by the European Union

T ented b pour la Recherche Stratégique

CONTACTS

European Union EXTERNAL ACTION

European External Action Service (EEAS)
EEAS Building, Rond-Point Schuman 9A
1040 Brussels, Belgium
eeas.europa.eu

Fondation pour la recherche stratégique

Fondation pour la Recherche Stratégique (FRS)
55 Rue Raspail
92300 Levallois-Perret, France
frstrategie.org