Valdai Discussion Club Report

The Shoot Down/Miss the Target Dilemma: The Evolution of Missile Defense and Its Implications for Arms Control

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Introduction

The worsening international military and political situation compels experts, time and time again, to focus on missile defenses. Heightened missile threats stimulate the development of defensive capabilities. Traditionally, missile defense is seen as a destabilization factor as well. The purpose of this paper is to identify fundamental trends and key problem areas and present proposals for potential solutions to minimize the negative implications of missile defense development for international security.

Trends

Missile defense as an element of integrated aerospace defense architecture

Traditional Cold War era ABM defense doctrine was based on two pillars: the idea of protecting a portion of national territory against a strategic intercontinental ballistic missile (ICBM) strike and the perception of ABM defense as a self-sufficient component of national defense. The 1972 ABM Treaty, which drew a line between missile defense and other defensive systems, can be considered the high point of this approach.[1] It affected terminology as well. For example, in Russia, the term "ABM" (*PRO, protivoraketnaya oborona*) was used to designate anti-ICBMs sytems and did not include operational/tactical defensive means. A similar idea prevailed in the United States, where missile defense systems were designated *Anti-Ballistic Missile Systems*, whereas operational/tactical defensive weapons were referred to as *Ballistic Missile Defense Systems*. Despite these terms sounding similar the underlying concepts were quite different.

This approach, however, was unsustainable in the long run. The fast-paced development of communications and hardware/software systems for gathering and processing information which generated the theory of "network-centric warfare" has, in real life, contributed towards the creation

[1] In particular, Article VI of the Treaty directly obliged to create separate missiles, launchers and radars to combat strategic ballistic missiles, prohibiting adaptation of any other defensive means to these purposes.

of all-purpose defensive architectures relying on a unified battle control loop and integration of sensor and fire power capabilities of various types. This trend was instigated by the same logic that lied behind the concept of “entanglement” of nuclear and conventional offensive weapon control systems.[2] The difference lies in the fact that this process has long become a reality in missile defense and is unfolding with minimal public exposure.

As a result, Russia (a little earlier) and the United States (somewhat later) decided that they needed to develop integrated aerospace defense systems that included a variety of surveillance elements (sensors, satellite surveillance equipment and radars) and a set of fire weapons that could intercept not only the typical ballistic and aerodynamic targets, such as ballistic missiles, manned aircraft and subsonic cruise missiles, but other targets as well, such as hypersonic cruise missiles, hypersonic glide vehicles, unmanned aerial vehicles (UAVs) and spacecraft, as well. The main driver is the growth in the scale and variety of missile threats coming not only from the great powers, but from third world countries and non-state actors as well.

Developing a unified battle control loop and its consequences

The practical implementation of an integrated aerospace defense system requires the creation of a unified battle control and communication loop that ensures the rapid gathering, processing, integration and transmission of information from sensors of various types. Such a loop acts as the “brain” of defense architecture, the cognitive abilities of which directly affect other elements’ effectiveness when addressing interception assignments.

Contemporary views imply integration of the broadest possible range of distributed sensors and fire weapons. In fact, it is the opposite of the earlier concept of delimiting defensive systems where each one relied on an autonomous battle control system and its own interception capabilities.

The US global missile defense system is an outstanding case of practical implementation. Fully cognizant of the fact that missile threats cross the

2 See Acton J. Escalation Through Entanglement: How the Vulnerability of Command-and-Control Systems Raises the Risks of an Inadvertent Nuclear War // International Security. 2018. Vol. 43, No. 1. P. 56–99; A. Arbatov et al. Entanglement: Chinese and Russian Perspectives on Non-nuclear Weapons and Nuclear Risks / ed. By J. Acton. New York: Carnegie Endowment for International Peace, 2017.

boundaries of responsibility of regional commands and branches of the armed forces, the United States has been talking about the need to integrate various defense systems since the early 2000s. Its long-term goal is to implement the *any sensor/any shooter* concept where data from all types of sensors are fed to a unified battle control loop and are then sent to the specific fire weapons that are most suitable for intercepting specific targets at a particular point in time.

The Command and Control, Battle Management, and Communications (C2BMC)[3] system, which is being doggedly developed by the US forces provides for the integration of various missile defense systems, such as the Patriot, Aegis, THAAD or GMD. Its current version, 8.2-3 works with information from the areas of responsibility of the Northern, Indo-Pacific, European, Central and Space Commands of the US armed forces, data from SBIRS satellites, information provided by long-range radars in Alaska, California, Greenland, Britain and Norway, and also from mobile radars AN/TPY-2, SBX and AN/SPY-1. It supports the *engage-on-remote* capability for Aegis systems[4], provides information to the GMD exo-atmospheric interception system, counteracts enemy electronic warfare and maintains communication between Combatant Commands and missile defense systems.

The next version 8.2-5 should provide fire weapons with information making it possible to intercept hypersonic systems, to expand the Northern Command and the Space Command's defense areas by way of hooking up a new Long-Range Discrimination Radar (LRDR) and to receive data from the US Army's Integrated Battle Command System (IBCS) and US Space Force's Space Kill Assessment (SKA).[5] Review reports covering US missile defense policy in 2019 and 2022 focus on the need to integrate the systems that are in service with US allies, such as the Israeli-American Kipat Barzel (*Iron Dome*), Hetz (*Arrow*) and Kela David (*David's Sling*) systems, British-French-Italian SAMP/T systems with Aster interceptors, and Norwegian-American NASAMS systems.[6]

In the future, various space sensors will be interconnected so that information is processed in orbit rather than with land-based infrastructure as things go now. This is what DARPA's Blackjack project is supposed to do when

[3] Command and Control, Battle Management and Communications // Missile Defense Agency. 22.08.2022.

[4] Engage-on-remote is a combat mode where the Aegis system points and launches an anti-missile, intercepts a target and confirms the hit relying only on external sensor data.

[5] See MDA FY 2022 Budget Estimates. P. 4.

[6] See 2019 Missile Defense Review. P. 71, 77; 2022 Missile Defense Review. P. 7, 10.

it's ready. New space sensor programs will maintain direct communication between satellites, for example, through the National Defense Space Architecture (NDSA) or the Resilient Missile Warning Missile Tracking – Medium Earth Orbit.

The US also develops the *left-of-launch* capability, the effectiveness of which requires integration of offensive weapons as well. In the United States, *missile defeat* before launch has officially become part of the missile defense strategy in 2019.[7] In review reports on US missile defense policy in 2019 and 2022, the need for integration is mentioned, among other things, as part of countering the enemy's anti-access/area denial (A2/AD) capabilities in certain regions.[8] Technically, integration is expressed, for example, as "using the same network of sensors and radars to intercept missiles or to detect and destroy them before launch."[9]

Creating the Joint All-Domain Command and Control (JADC2) will be the next phase of integration in defense systems alone and in combination with offensive weapons.[10] It's this particular phase that the any sensor/any shooter concept is planned for implementing.

The Russian Armed Forces are also on the way towards creating integrated layered defensive systems,[11] which have of late been enhanced with the anti-missile functions. That goes for the anti-aircraft systems in service and for the air defense systems that are integrated with the Moscow Region missile defense system. A study is in progress to test the interoperability of complex systems for detecting and intercepting hypersonic targets that include existing fire power (in particular, S-300V), and advanced

[7] 2019 Missile Defense Review. P. 60. "Missile defeat" comprises all activities aimed at preventing the enemy from purchase, proliferation, potential or actual use of offensive missiles or at limiting damage caused by them (See: 2022 Missile Defense Review. P. 1). "Left-of-launch capability" is only part of such measures which includes using offensive means, electronic warfare tools and cyberweapons to prevent the enemy from launching missiles. On the integration of US missile and anti-missile systems, see: Green B. Offense–Defense Integration for Missile Defeat: The Scope of the Challenge. Washington: Center for Strategic and International Studies, 2020.

[8] 2019 Missile Defense Review. P. 34; 2022 Missile Defense Review. P. 10. Anti-access/area denial (A2/AD) potential includes enemy's anti-air/anti-missile systems, anti-ship coastal missile systems, as well as short-, medium- and intermediate range missiles used for theater interdiction.

[9] 2019 Missile Defense Review. P. 34.

[10] Normally, US military and political documents mention five environments, namely, sea, air, land, outer space and cyberspace.

[11] Borisko S.N., Goremykin S.A. Analysis of the State of the Russian Air and Space Forces. Development Prospects [Analiz Sostojanija Vozdushno-Kosmicheskih Sil Rossii. Perspektivy razvitija] // Military Thought [Voennaja mysl']. 2019. No. 1. P. 25-37

surveillance tools, such as low-orbit satellites and high-altitude balloons.[12] By the late 1970s, the exchange of initial data between missile defense, missile alert and space monitoring systems had already been established.[13] In the future, the Russian aerospace defense system should be able to detect and destroy ballistic and hypersonic targets along the entire length of the flight trajectory.[14]

The development of unified battle control loops will have important implications for strategic stability. **First**, countermeasures are being developed in the form of offensive anti-space weapons and non-kinetic means such as cyber weapons and electronic warfare. **Second**, the "entanglement" of automated battle control systems for offensive and defensive weapons will increase. In this regard, the attempts to exert external influence on the infrastructure that is used in the operation of such loops in the future will involve increased risk of misreading intentions, undermining crisis stability and unintended escalation.

Developing missile defense sensor potential

There are five key priorities in the efforts to strengthen missile defense sensor capabilities: **1)** boosting the efficiency of detecting and tracking targets, including before launch; **2)** increasing the number of concurrently tracked targets; **3)** discrimination of warheads and decoys in the threat cloud; **4)** detecting and tracking cruise missiles; **5)** locating and tracking hypersonic weapons.

Implementation of these priorities involves the deployment of new over-the-horizon tracking radars;[15] development of tracking sensors for

[12] Smirnov D.V., Shuvertkov V.V. A Difficult Task, but Solvable [Zadacha Trudnaja, no Reshaemaja] // Aerospace Defense [Vozdushno-Kosmicheskaja Oborona]. 2015. No. 1. P. 33-39

[13] "Warned Means Protected". Interview with A.V. Revenok, Head of the Main Center for Missile Attack Warning of the Space Forces of the Aerospace Forces [«Preduprezhdjon – znachit zashhishhjon». Interv'ju s nachal'nikom Glavnogo centra preduprezhdenija o raketnom napadenii Kosmicheskih vojsk Vozdushno-kosmicheskih sil A.V. Revenkom] // Red Star [Krasnaja Zvezda]. 15.02.2021.

[14] Meeting with Defence Ministry Leadership and Defence Industry Heads // en.kremlin.ru. 01.11.2021.

[15] The state-of-the-art systems of this type include the Russian 29B6 Container (see: Nersisyan L. What is Russian "Container" radar capable of? [Na chto sposoben rossijskij radiolokator «Kontejner»?] // Regnum [Regnum]. 04.12.2019) and the advanced American TACMOR radar (see: Persistent Stare // Missile Defense Advocacy Alliance. 11.02.2022).

mobile launchers;[16] construction of new land-based long-range target discrimination radars;[17] deployment of space sensors for detection, tracking and discrimination of targets, including hypersonic targets;[18] development of air-based sensors for tracking cruise missiles;[19] and building up the sensor capabilities of regional missile defense systems to hit complex targets.[20]

From the point of view of strategic stability, the effects of strengthening the missile defense sensor potential appear to be mixed. Increased protection against limited cruise missile and hypersonic weapon strikes on targets located deep into enemy's territory could raise the threshold for the use of nuclear weapons. However, a potential solution to the challenge of discriminating actual warheads in a target cloud carries the risk of undermining the capability for a retaliatory strike by the countries that are committed to minimal deterrence and not seeking strategic parity.

One can predict increasing interest in suppressing the enemy's sensory potential through the use of cheap and mass-produced offensive means. Anti-satellite systems capable of "blinding" the orbital sensor architecture similar to the Russian Peresvet military laser will be developed. Finally, the concept of destroying satellites with long-range interceptor missiles will expand and lead to the merging of the missile defense strike elements with space weapon defense systems further exacerbated by an accelerated space arms race. The development of sensors to support left-of-launch interception which leads, **first**, to a significant loss in security for retaliatory forces, and, **second**, to a decrease in the staying power of weapons in the theatre are worth a separate mention. In both instances, the loss of confidence in the survivability of available forces may push to adopt doctrines that shift the emphasis to the pre-emptive use of weapons, including nuclear ones.

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[16] The American GMTI program. See: Albon C. US Space Force Wants Funding For a New Mission – Tracking Ground Targets. // DefenseNews. 19.01.2022.

[17] The American LRDR radar (See: Judson J. US Missile Defense Agency Declares Initial Delivery of Long-Range Discrimination Radar in Alaska // DefenseNews. 07.12.2021).

[18] The American HBTSS, NDSA, and OPIR programs (For an analysis of their capabilities see: Hudson

L. U.S. Space Force Juggles Changes To Missile Warning Portfolio // Aviation Week & Space Technology. 19.03.2021).

[19] The American JLENS project (See: Judson J. Long Live JLENS? NORTHCOM Scrambles on Cruise Missile Defense // DefenseNews. 24.06.2016).

[20] The advanced American AN/SPY-6 and LTAMDS radars for Aegis and Patriot systems, respectively (More on LTADMS in: Mayfield M. Army Revamps to Pursue New Air-and-Missile Defense Tech // National Defense. 12.05.2021; on the upgrade of AN/SPY-6, see: Navy Aegis Ballistic Missile Defense (BMD) Program: Background and Issues for Congress // Congressional Research Service. 20.10.2022. P. 26).

Proliferation of missile defense technologies

Nowadays missile defense technologies are maturating and spreading at an accelerated pace. The traditional leadership of the United States and the Soviet Union/Russia in this area are still beyond reach for other players, but an increasing number of them are showing an interest in developing national defense systems both individually and within international cooperation. Israel leads as the only country that has managed to deploy a relatively effective layered missile defense system to protect the national territory.

India is focused on improving its missile defenses as well. In 2020, it completed two-layer area defense system tests around New Delhi. Its fire components include PAD and AAD long-range and medium-range anti-missiles.[21] In 2018, India concluded a contract with Russia for five S-400 systems capable of hitting medium- and shorter-range airborne targets.

Other major players include China with its Hong Qi (*Red Banner*) long-range mobile air defense systems; Taiwan with Tien Kung (*Sky Bow*) anti-ballistic missile system; and Iran, which has developed the Bavar-373 (*Belief/the Messenger of Allah*) long-range air defense system. South Korea is in the process of building the Korean Air and Missile Defense (KAMD) system to be deployed in the 2020s. The EU is looking into creating its own missile defense system, which can draw on the Franco-Italian experience of developing Aster anti-missiles. In August, German Chancellor Olaf Scholz proposed creating such a system, which was widely supported by the EU members.[22]

Many countries prefer to purchase missile defense systems from the leaders in order to avoid the high outlays and technical complexities involved in creating their own defensive means. The leading suppliers include the United States, Russia and Israel. US defense corporations are developing international missile defense cooperation as they pursue joint programs with Israel and Norway. In turn, Washington's allies get the chance to join the implementation of US missile defense programs. For example, Japan successfully participated in

[21] Snehesh A. India's Ballistic Missile Shield Ready, IAF & DRDO to Seek Govt Nod to Protect Delhi // ThePrint. 08.01.2020.

[22] Witzel M. Twelve European States Poised to Join Scholz's Anti-Missile Shield // EurActive. 13.11.2022.

designing the SM-3 Block IIA[23] interceptor. All of the above expands US alliances and reinforces horizontal ties between the defense industries of the United States and its allies.

The spread of missile defense technology makes maintaining leadership in this area dependent on the leading states' willingness to expand research and production cooperation, as well as on their ability to supply integrated defense systems. There is a growing demand for integrated solutions that imply, in addition to air defense systems, the supply of a wide range of associated equipment, primarily compatible external sensors. The above arrangement can be used to supply all-in layered defensive solutions, including surveillance and fire means of varying ranges (with the option to integrate them into a client's existing weaponry) that have been assembled to fit a unified combat command and control loop.

Missile defense as an element of counterforce capability

The key missile defense systems-related issue of strategic stability is the fact that they can't be definitively classified as defensive or offensive weapons. Taken individually, they appear to be a means of repelling enemy missile attacks and, therefore, a defense tool. In particular, the Israeli Kipat Barzel (*Iron Dome*) system was designed to repel massive missile or artillery barrages by non-state actors. However, the global missile defense system being created by the United States is not capable of repelling a massive missile attack today and will not be capable of doing that in the foreseeable future. American declarative policy is still based on the principle of deterring missile attacks from Russia or China through the threat of retaliation.[24] Missile defense is positioned as an instrument of repelling limited missile strikes from North Korea or Iran.[25]

If we rule out the scenarios of unauthorized launches or terrorist attacks with the use of hi-end ballistic missiles and consider missile defense as a

[23] Fashola K. Five Types of International Cooperation for Missile Defense. Washington: Center for Strategic and International Studies, 2020. P. 4.

[24] 2022 Missile Defense Review. P. 5.

[25] Ibid, P. 6.

tool to counter a limited missile strike (the so-called "thin" missile defense concept), then its effectiveness will largely depend on the scale of the attack. As a result, the owner of a "thin" missile defense system starts developing a natural interest in expanding his counterforce strike capability, which implies maximizing pre-emptive damage to enemy strategic forces before they are even used.

The US expert community is engaged in lively debate over the practicability of such a scenario.[26] These prospects cause great concern on the part of America's strategic rivals Russia and China, forcing them to work on the complex task of overcoming missile defense.

The US efforts to strengthen counterforce capability are among the key reasons behind the erosion of strategic stability. They amplify uncertainty and increase the risk of misinterpretations by other countries. The capability-based rather than threat-based principled position of the United States on the issue of designing military programs, which it has been promoting since mid-2001, has led to the creation of all-purpose systems of weaponry and military equipment that can be used in a variety of ways to provide a flexible response to emerging threats. At the same time, this leads to a broad interpretation of the programs being implemented by potential adversaries, something that fuels the arms race.

Developing advanced technologies and technological breakthroughs in missile defense

Speaking of breakthrough technologies, the following key areas for improving missile defense systems can be implemented in the medium term, namely, direct energy weapons (laser and microwave) and "dust" weapons.

The key advantages of *laser weapons* include low cost of interception compared to anti-missiles, virtually unlimited ammo, and quick target destruction. However, they only operate within line-of-sight range which is limited due to beam scattering in the atmosphere, are sensitive to weather,

[26] See Lieber K., Press D. The New Era of Counterforce // International Security. 2017. Vol. 41. No. 4. P. 9–49.

and do poorly against a massive missile strike.[27] In a ballistic missile attack, the laser can be ineffective due to the missile's short boost phase, multifunctional protective coatings and trajectory maneuvers, including the ability to roll on its axis.

Most likely, the first operationally ready mass-produced missile defense laser will be used to counter cruise missiles and UAVs. In May 2022, US Deputy Secretary of Defense for Research and Engineering David Honey argued that lasers would be used to intercept cruise missiles in the short term, hypersonic missiles in the medium term, and ballistic missiles in the long term.[28]

This is also being accounted for in the capacity of newly created equipment. The maximum power of the missile defense laser prototype that was created in the United States does not exceed 130 kW which can only handle cruise missiles or blind an enemy's sensors. Intercepting ballistic missiles requires a power of 500 kW or more, but only during the boost phase and from a short distance.[29] An experimental unit based on a Boeing 747-400 with a chemical laser created by the United States in the early 2000s was a failure with its low combat stability, cumbersome usability, and extremely high cost which led to the closure of the corresponding ABL program in 2012.

The attempts to create a laser to combat UAVs continue unabated, but this time as a fiber combining laser or a diode-pumped alkali laser. This is where the second problem of laser systems – the weight and dimensions – comes in. The ABL program laser had a specific gravity of 55 kg/kW, with a target of 2 kg/kW for the effective implementation of this equipment.[30] Nevertheless, the possibility of attaching lasers to other types of mobile platforms (ground or surface) remains.

Since at least the 2000s, Israel has been developing missile defense lasers. The Keren Barzel (*Iron Beam*) laser with a power of up to 100 kW was

[27] Fedasiuk R., Reif K. Reasons to Doubt Laser Missile Defense // Arms Control Association. 14.05.2022.

[28] Statement of David A. Honey, Deputy Under Secretary of Defense for Research and Engineering // Senate Armed Services Committee. 18.06.2022. P. 2.

[29] Schneider W. High Energy Lasers: Applications for Ballistic Missile Defense. Defense Technology Program Brief No. 16 // The American Foreign Policy Council. Dec. 2016.

[30] Ibid.

developed.[31] By March 2022, it had been tested against UAVs, unguided missiles and guided anti-tank missiles.[32] Talks are underway to export this system to the UAE and Saudi Arabia.[33] Japan[34] and Britain[35] have also said they have started research on missile defense lasers.

Ample research is conducted on *electromagnetic (microwave) missile defense systems* of pulse or continual action. The former is designed for short-term powerful impact in a small amount of space in order to disable a target's on-board electronics. The latter is designed to use less power and is mainly intended for jamming. Both types have a broad focus on a target area, which potentially makes it possible to launch a simultaneous attack on a clustered air target (lasers cannot do this due to their coherence).[36]

The electromagnetic weapons' disadvantages stem from the enemy potentially using countermeasures, and from increased energy consumption, short range, and dependence on the state of the atmosphere (due to unstable conditions for propagation of electromagnetic radiation).

A notable project in this regard began in the winter of 2022 at the US Naval Surface Warfare Research Center. Its main goal is to develop the architecture of an integrated close range ship missile defense system that combines laser and electromagnetic weapons in a unified battle control loop. The latter is assigned tasks ranging from suppression of the attacking missiles or drones' on-board electronics to its "physical destruction."[37]

It is indicated separately that electromagnetic systems can also be used against manned aircraft with "non-lethal consequences." It should be

[31] Ahronheim A. Lockheed Martin, Rafael Advanced Defense Systems to Make New Laser Weapon // The Jerusalem ost. 27.07.2021.

[32] Fabian E. In 'Game Changer,' Israeli Laser-based Air Defense Shoots Sown Drones // The Times of Israel. 14.04.2022.

[33] Israel To Ask Biden for Okay to Provide Air Defense Laser to Saudi Arabia – Report // The Times of Israel. 28.06.2022.

[34] Takahashi K. Tokyo Urged to Increasingly Focus on High-Power Microwave- And Laser-Based Weapons // Janes. 29.03.2021.

[35] Chuter A. UK Shoots for New Laser Weapons Against Drones, Missiles // Defense News. 09.07.2019.

[36] Department of Defense Directed Energy Weapons: Background and Issues for Congress // Congressional Research Service. 13.09.2022. P. 20–22.

[37] Tingley B. The Navy Is Betting Big On High-Power Microwave Weapons // The Drive. 07.01.2022.

noted that there is a likelihood of incidents, including incidents involving human casualties, due to the loss of aircraft control[38] while flying around a ship with this system; the risk of using "non-lethal" weapons like a warning shot are significantly higher than in the case of using conventional air defense systems.

"Non-kinetic" means of disabling a missile forces' infrastructure are of particular importance. The basic technology package includes the entire set of electromagnetic means of suppressing on-board electronics of missiles, sensors, means of electronic intelligence, as well as communication and battle control systems. The often cited arguments about the "reduced lethality" of such weapons can hardly be taken seriously, given the context of the conflicts in which they would be used as part of a unified missile defense loop. However, these arguments can be used during a military-political crisis as justification for their use based on the allegedly lower potential for escalation.

The suppression of satellite communications and global positioning system signals, which can affect several processes concurrently, is among the channels of impact during the launch of missiles and after it. These processes include the timely transmission of the firing command, the clarification of the coordinates of the launchers at the starting point (if a pre-calculated combat position has not been selected), as well as in-flight adjustment (if a missile has a satellite channel for clearing accumulating navigation errors). In addition, suppressing the missile's communication channels deprives an enemy of two important capabilities: telemetric control of the process and the result of hitting the target, and, in particular, flexible in-flight retargeting capability (which is a standard option on modern US cruise missiles).

Remarkable results for non-kinetic left-of-launch interception can come from the use of offensive electromagnetic weapons. The US CHAMP project provided for the creation of a special type of payload for the AGM-86C cruise missile that damages electronics. By the late 2010s, the US Air Force obtained at least 20 sets of such weapons. In July 2022, it was announced that under the HiJENKS project work had begun on developing the next generation of systems of that kind designed to be mounted on the AGM-158B JASSM-ER cruise missile platform.[39]

[38] The studies of the powerful microwave radiation's impact on human body (related to the operation of radars) shows that its "non-lethality" does not mean it is not bad for human health.

[39] McGonegal J. High Power Microwave Weapons: Disruptive Technology for the Future. Maxwell: Air Command and Staff College, 2020. P. 6–8.

These systems can be securely directed into the missile deployment areas from a long distance. In the first hours of hostilities, they can suppress the enemy's automated communications and battle control systems. Loitering ammunition with a similar combat payload on board may also be of interest. While on duty in a missile deployment area, they can either wait for an external command to launch, or independently determine the target (a launched missile, a launcher or radar) and use an electromagnetic weapon to attack it.

A "dust cloud" is considered an alternative to the traditional kinetic option of defending against hypersonic cruise missiles and hypersonic glide vehicles.[40] The concept goes back to the study of the "fratricide" issue in a multiple attack against a single target or a group of densely spaced targets: the destruction of subsequent nuclear warheads by the caked-on particles of ground lifted into the air by the first blast.[41]

The idea is to eject a wide cloud of artificially created solid particles with certain specifications ahead along the trajectory of a hypersonic vehicle, which can stay in the atmosphere for a fairly long time (unlike a damaging cloud of large shrapnel). A high impact speed leads to damage to the ablation casing of the target, which in the middle part of its trajectory (where this "dust" is to be used) can lead to the loss of controllability and even destruction due to unacceptable thermomechanical effects.

The scientific and technical research on this issue is extensive: for decades, the interaction of small particles in the atmosphere with descent space modules and missile warheads at high impact speeds has been studied in depth. The research results can be implemented for missile defense needs fairly quickly, if the dust cloud-against-a-hypersonic-target arrangement proves to be viable.

In general, a distinct shift in developing innovation technologies can be clearly seen. It's about creating systems that look more usable than conventional "kinetic" weapons, but at the same time can impact sensitive elements of military infrastructure. This increases the risk of using them in a crisis situation and at the same time pushes for a decrease in assessment of the combat stability of key potentials against such a system. Clearly, there's a problem of violating

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[40] Karako T., Dahlgren M. Complex Air Defense. Countering the Hypersonic Missile Threat. Washington: Center for Strategic and International Studies, 2022. P. 37–38.

[41] Lieber K., Press D. Op. cit. P. 21–22.

crisis stability associated with the military-technical implementation of the "stability/instability paradox." In addition, laser and microwave weapons will vastly enhance the potential for intercepting targets at close range.

The issue of launching weapons into space "based on new physical principles" which also includes direct energy weapons is among the long-standing (since SDI) sticking points between Russia and the United States. This scenario remains extremely unlikely, or at least, remote. The development of the missile defense space echelon in the medium term will most likely come down to a quantitative increase and qualitative improvement in orbital sensors. Deploying orbital offensive systems is fraught with fatal shortcomings, including operational and financial shortcomings, and is highly vulnerable to attacks by cheaper anti-space weapons (not to mention mounting incentives to develop and deploy them as countermeasures).

Issues

Forward deployment (Europe, Middle East, Indo-Pacific)

Missile defense system development provides for deploying this infrastructure outside national borders. For example, Russia deployed its S-300/400 systems in neighboring Belarus and in Syria to protect military bases in Tartus and Khmeimim. For a long time, it operated the missile alert elements that ended up outside its borders after the breakup of the Soviet Union, in particular, the Gabala radar station in Azerbaijan and the Volga radar station in Belarus. However, the US missile defense program stands apart in terms of its massive scale and extensive geography of deployment.

In the long term, elements of the US ally-operated regional missile defense system will be integrated into a unified architecture with US missile defense systems in a particular region. So, it is important to take into account that America's allies possess the air defense weapons that have been tested against short-range cruise missiles and ballistic missiles.

Russia and China regard forward deployment of elements of the US regional missile defense architecture as a threat.

Moscow has officially denounced the deployment of Aegis Ashore systems in Europe, either because of their capability to intercept Russian ballistic missiles, or due to the capability to use medium-range cruise missiles from Mk.41 universal launchers against strategic targets in European Russia. But, the main reason behind Russia's concern is the fact that these means enhance the ability to detect launches and to track ballistic missiles during the boost phase. The maximum range of the AN/SPY-1 radar which is part of the Aegis systems is about 550 km.[42] The Aegis Ashore systems can be equipped with new advanced AN/SPY-6 radars whose range is 3.2 times further[43] and makes it possible to detect ICBM launches from European Russia. When integrated via C2BMC, these data can be used in the interest of the US national missile defense system.

In turn, in 2017, China responded negatively to the deployment of a THAAD system battery outfitted with an AN/TPY-2 radar in South Korea. This is not a threat to Chinese ICBMs in and of itself, but it can reduce the vulnerability of US military sites in Japan, and especially in South Korea, to Chinese medium-range ballistic missiles. The AN/TPY-2 radar unit can also be used to detect ICBM launches and to support the US national missile defense system with the use of C2BMC.

In addition to Russia and China, the development of forward-based US missile defense components is making the DPRK and Iran, against which this missile defense arthitecture is being officially created, to wary. On the one hand, this encourages them to further improve their missile arsenals, and, on the other, it lays the groundwork for consolidating international opposition to US missile defense efforts.

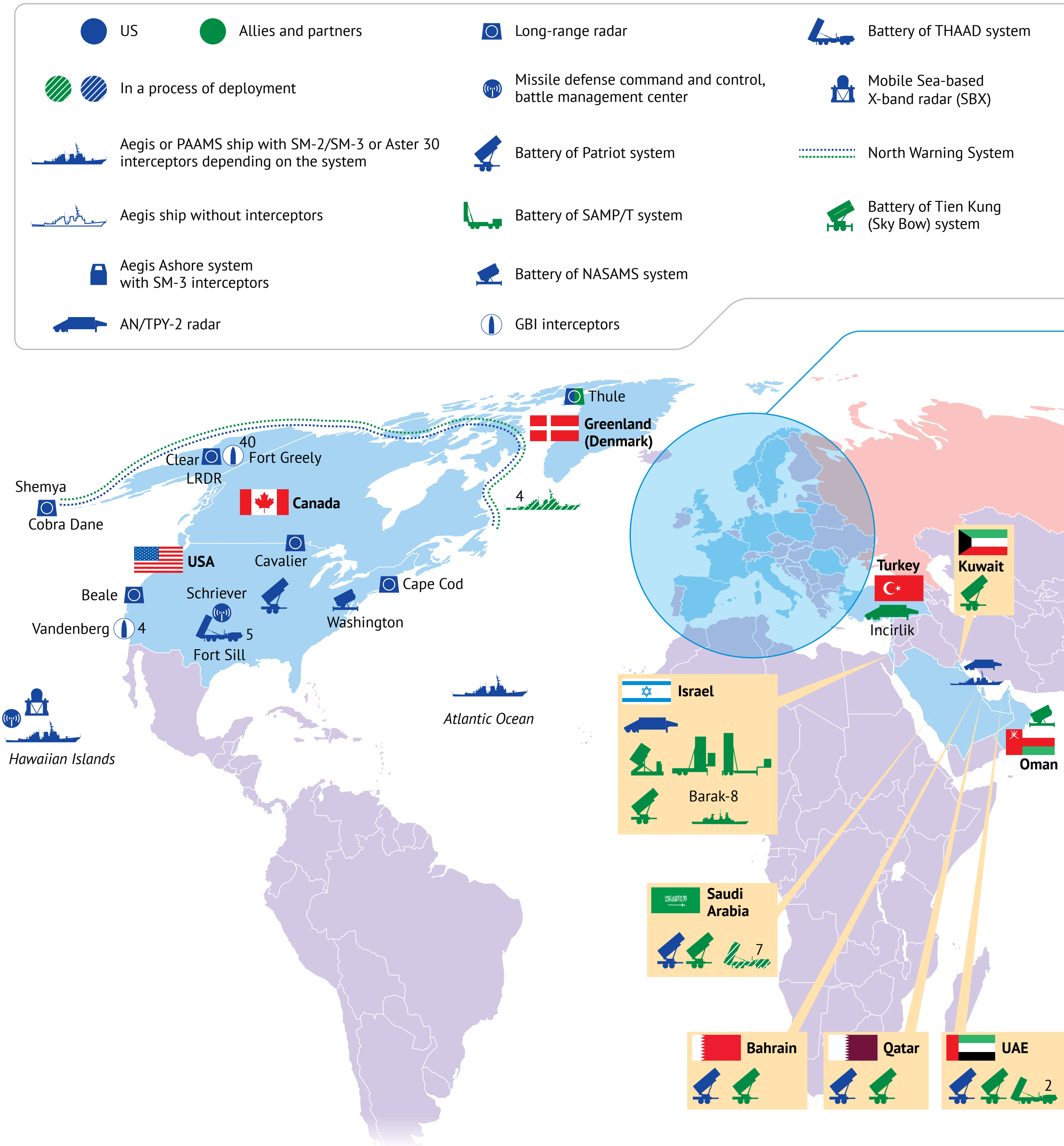
Stimulating a qualitative and quantitative arms race

The unchecked development of missile defense systems is forcing nations to look for ways to overcome it reliably with consideration for the realities that may materialize in the distant future. What follows from that directly is an increase in the number of weapons (primarily ballistic missiles, including missiles with MIRVs, as well as long-range cruise missiles and

[42] Lewis G., Postol T. Ballistic Missile Defense: Estimating the Range of an Aegis Radar Against a Missile Warhead Target // Mostly Missile Defense. 23.11.2012.

[43] Sankaran J. New Aegis Radar to be 100 Times More Sensitive than Current Radar // Mostly Missile Defense. 22.06.2019.

MISSILE DEFENSE ELEMENTS OF THE UNITED STATES, ITS ALLIES AND PARTNERS




Over-the-Horizon radar
Battery of Kippat Barzel (Iron Dome) system
Battery of Kela David (David's Sling) system
Battery of Hetz (Arrow) system
Vardø
Norway
Sweden
Russia
PAAMS
Great Britain
Netherlands
Lithuania
Fylingdales
14
12
Redzikowo
2
Poland
Ramstein
France
Germany
Romania
Italy
Deveselu
5
PAAMS
PAAMS
Spain
4–6
Rota
7
20
7
8
South Korea
8
8
4
Yokota
Shariki
Kyogamisaki
Japan
Guam (USA)
Taiwan
Australia

hypersonic weapons) including improvements in quality (more sophisticated trajectories, increased accuracy, longer range, higher speed and smarter on-board control systems).

Taking into account the lengthy development cycles, production and deployment of strategic missile weapons, we can safely assume that the foundation for a multilateral arms race has been laid for decades to come. The main actors will include the group of five nuclear countries (P5) and nuclear countries outside the Non-Proliferation Treaty (NPT), as well as ambitious regional powers like Turkey, Iran, and the Arab Gulf monarchies. With a high degree of probability, this process will affect Poland, other countries in Northern, Central and Eastern Europe, and Southeast Asia, with an emphasis on developing long-range anti-ship missiles, inclusive.

The key priority for the technology leaders now is to "hedge" against threats by developing innovative delivery systems and anti-missile system's penetration aids with an emphasis on breakthrough technologies, in particular:

1. Hypersonic offensive systems (including ones with higher levels of AI implementation);

2. Fractional orbital missile systems (including dual-equipped);

3. Non-conventional offensive weapons (Poseidon nuclear-powered unmanned underwater vehicle and Burevestnik nuclear-powered unlimited-range cruise missile).

Prospects and limitations for using missile defense arms control tools

The current international environment, which is marked by a growing exacerbation of rivalry between the great powers, is objectively not conducive towards adopting international restrictions on missile defense development. In recent years, we have witnessed landslide degradation in the arms control system. It can be stated that arms control and limitation processes have become secondary to the intensifying arms race, one of the key dimensions of which is the development of missile defense systems.

Missile defense is going through a new phase of technological development, the actual potential of which has yet to be realized. The advanced solutions that are theoretically capable of enhancing the capabilities of missile defense systems are still in the research and development phase, which is much more difficult to limit and control than the deployment and operation of stock-produced items. Power-wielding lobbying coalitions advocating against any limitations on missile defenses have formed within the decision-making communities of many countries, especially the United States. The international situation is making their position stronger and is shaping the context for the development of the theses on "the need to maintain technological edge in a competitive environment" and "strengthening the country's defense in the face of mounting external threats."

The main focus of missile defense development lies in integrating all available potential within complex layered systems outfitted within a unified control loops. Pursuit of this path will lead us to a place where limitations of individual missile defense components (primarily sensors and control systems) may potentially lead to a major decline in the entire system's effectiveness, which, in turn, will become an additional barrier to implementing arms control measures.

The key players' approaches do not inspire optimism, either. On one hand, in its National Security Strategy 2022, the United States declares its push to lead "bilateral and multilateral arms control efforts" and designates its readiness to cooperate with China and Russia in this area even in the face of exacerbated mutual rivalry.[44] The US Missile Defense Review of 2022 has for the first time codified the "interrelationship between strategic offensive arms and strategic defensive systems"[45] at the doctrinal level.

However, this language sounds more like an invitation to talk rather than a sign of willingness to strike a compromise. In practice, the United States' position still relies on a request-based approach. With regard to Russia, the goals of maintaining the limits imposed by the 2010 New START Treaty, limiting

[44] 2022 National Security Strategy. P. 25-26, 30. Notably, this approach replicates the position of the Soviet Union in the 1970s, when arms control was seen by Moscow as a separate element of Soviet-American relations not tied in with the general political context. The US leadership, on the contrary, strived to tie it in with other bilateral issues. As a result, President Carter administration used the entry of Soviet troops into Afghanistan in December 1979 as a pretext for revoking the SALT-2 Treaty from ratification. (See: Oyos M. Jimmy Carter and SALT II: The Path to Frustration // American Diplomacy. Dec. 1996).

[45] 2022 Missile Defense Review. P.6. The corresponding principle was enshrined in the 2010 Prague START Treaty, but never made it to high-level US strategic documents.

new types of nuclear weapons and establishing a single cap on all nuclear warheads (including non-strategic ones)[46] have been declared. With regard to China, it's about establishing constructive interaction and dialogue with the aim of achieving transparency and mitigating strategic risks.[47]

Russia insists on developing a "security equation" that will take into account all factors affecting strategic stability.[48] China is trying to reduce its involvement to general consultations of the five nuclear powers and avoid being involved in full-scale bilateral cooperation with the United States amid the persisting inequality in strategic potentials.[49]

The difference in the three countries' declarative approaches to the issue of arms control shows that they are not ready for deep interaction. But even in these circumstances, the parties could streamline missile defense development without the risk of being accused of "unreasonable concessions" or "losing face." Maintaining and expanding the dialogue between expert communities is of paramount importance, and is becoming even more important in the context of a brutal crisis in strategic communications. There is a potential to resume official consultations on common issues like missile defense doctrines, unification of the terminology, strategic risks control or developing approaches to information exchanges with an eye towards maintaining the transparency of military programs.

Importantly, the above can be integrated into existing interaction formats, primarily, the P5 dialogue. China came up with such a proposal during the last NPT Review Conference, but it went unnoticed amid multiple disagreements.[50] Involving other leading missile defense powers – Israel or India – in the dialogue may require the creation of a separate consultation mechanism.

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[46] Jenkins B. Priorities Regarding the New and Emerging Challenges to International Security // U.S. Department of State. 26.06.2022.

[47] Ibid, see.: Stewart M. Keynote Address for the Commemoration of the 50th Anniversary of the Arms Control Association // U.S. Department of State. 02.06.2022.

[48] Постникова Е. «Применение ядерного оружия возможно только в порядке ответа на нападение». Интервью с заместителем министра иностранных дел России С.А. Рябковым // Известия. 22.08.2022.

[49] Fu Cong. Upholding the Treaty on the Non-Proliferation of Nuclear Weapons for World Peace and Development.

// Ministry of Foreign Affairs of the PRC. 03.08.2022;.: Черненко Е. «Нам нужно сохранять

°пределённую степень двусмысленности для эффективности ядерного сдерживания». Интервью с директором Департамента по контролю над вооружениями МИД КНР Фу Цуном // Коммерсант. 16.10.2020.

[50] Fu Cong, op. cit.

Finally, it is possible to develop and implement confidence-building measures in missile defense, or to exchange notifications or inspections optionally. In some cases, the parties could take unilateral initiatives to improve the international political climate and refuse to deploy the offensive systems in space or to impose a moratorium on testing anti-satellite systems against actual targets in orbit. However, agreeing on these is much more difficult than carrying out the two previous steps.

These initiatives should not be taken as a full replacement for comprehensive arms control measures in the sphere of missile defense. However, despite their limited nature, they can serve as a foundation for reaching more serious agreements in the context of future stabilization of the strategic situation.

Conclusion

The developments unfolding in missile defense are determined primarily by a set of defense and doctrinal trends. The architectural ideology underlying missile defense is being actively aligned. Ten to fifteen years ago, the Russian concept of a layered defense against “aerospace offensive weapons” looked like an artifact. However today, a similar approach can be seen in US missile defense plans.

Creating unified battle control loops for various defense systems has become an objective and an inevitable necessity due to expansion and complication of the range of missile threats. However, it also triggers the development of countermeasures including anti-satellite weapons. At the same time, the “entanglement” of control systems for various types of weapons is at risk of becoming a major source of escalation risks in the medium term.

Strengthening the capabilities of missile defense means improves its effectiveness, especially in terms of combating complex targets, such as hypersonic weapons and detecting enemy mobile launchers. The emerging risks may push the parties to start an offensive arms race and effect doctrinal shifts with an emphasis on pre-emptive actions by strategic forces.

There is an increase in global demand for missile defense systems. Maintaining leadership in this market depends primarily on the leading countries’ willingness to expand international scientific and industrial cooperation and to supply integrated defense solutions.

Direct energy weapons and “dust” defense capability stand out among other advanced missile defense technology breakthroughs. However, developing them will not lead to a drastic improvement in the effectiveness of missile defense; they are primarily designed to cover individual problem areas, such as addressing short-range interception goals. At the same time, there is a research and technology push to develop non-kinetic approaches that carry the risk of a psychologically more convenient use in a crisis situation and, consequently, the risk of escalation.

The logic behind missile defense system development stimulates the offensive and defensive arms race. Mounting international tensions put tight bounds on the parties’ ability to implement arms control measures. However, given the circumstances, it is particularly important to maintain channels of communication between key actors. It is useful to promote the dialogue at the expert level and to promote the discussion of missile defense at existing international platforms, in particular, among the P5.

In the case of Russia, it is advisable to draft and publish official declarative policy documents, for example, in the form of the Basic Principles of the State Policy of the Russian Federation in the Sphere of Aerospace Defense. A systematic and detailed description of Russia’s approach to limiting missile defenses with account taken for today’s realities in the military-strategic and international situation appears to be the most important component of such a policy.

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