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# The S-400 "Triumf": between expectations and results

**Col. adv.ins. Cătălin CHIRIAC, Ph.D.***

*"Carol I" National Defense University, Bucharest, Romania
e-mail: catalin_chi@yahoo.com

## Abstract

During the Cold War, the Soviet Union invested heavily in its air defense systems, so its rightful successor, Russia, has now some of the most advanced air and missile defense systems in the world. Among them, the S-400 "Triumf" surface-to-air missile system is perhaps the most criticized, shrouded in mystery, and feared system in Russia's arsenal. Developed and then presented as capable of engaging a variety of aerial threats, the system gained a reputation, at least declaratively, of being able to counter US and NATO ambitions to win a conflict through airspace dominance.

**Keywords:**

air defense system; surface-to-air missile system; S-400 "Triumf"; air defense; missile defense; integrated air defense; countering air threats.

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Air and missile defense is often perceived as that type of defense that protects an objective or surface against threats posed by aircraft, drones, or missiles, and the simple existence of a capable surface-to-air missile system induces the erroneous idea of total protection at the level of a country or theatre of operations. It must be well understood that a system designed to combat such threats will never be able to intercept any aircraft, drone or missile with high effectiveness, for technical, tactical or operational reasons.

The diverse air threats, and here we can mention hypersonic missiles and unmanned aircraft systems, have further exacerbated their qualities to the prejudice of the systems that should combat them. If hypersonic missiles are considered the perfect weapons for defeating any air or missile defense due to their main characteristic of manoeuvrability at hypersonic speeds, this does not directly imply that other air threats with subsonic or supersonic speeds cannot do so.

Russia's handling of the conflict in Ukraine, where neither side controls the airspace[1], provides far more questions than answers about the future of the systems that are supposed to be responsible for it. The owner of one of the largest and most sophisticated air forces in the world, at least according to the rankings of various publications, Russia did not succeed or, maybe did not even set out to obtain air superiority in Ukraine, which caused great surprise and perplexity among Western military analysts. Under these conditions, the ground base air defense component represented at the highest level by the S-400 " Triumf " systems[2], deployed in Belarus and Crimea[3], imposed the rules regarding the use of air space, the Ukrainian planes being forced to fly at extremely low altitude (below 100 ft) for the execution of missions on the northern and southern directions (Bronk, Reynolds and Watling 2022, 12).

## S-400 "Triumf" system

The S-400 "Triumf" system, developed by Russia's Almaz Central Design Bureau, is a long-range mobile surface-to-air missile system, capable of engaging aircraft, UAS's, cruise missiles and ballistic missiles and represents the fourth generation of Russian long-range systems. It is also the successor of the S-200 and S-300 systems, having been in service since 2007, but did not become operational until 2012 in Kaliningrad and in 2016 near Saint Petersburg (Dalsjö, Berglund and Jonsson 2019, 27). Development of the S-400 system probably began in the 1980s, with the developers' effort being kept secret from the public until 1993, two years after the collapse of the Soviet government (Hollings 2022). As with many Soviet weapons programs, which continued to be developed by the Russian Federation, budgetary constraints dictated that approximately 70% - 80% of the technology used by the original project be carried over and adapted from the S-300,

[1] N.A.: In the article *In denial about denial: why Ukraine's air success should worry the West*, the authors Maximilian K. Bremer and Kelly A. Grieco discuss, based on the actions carried out so far in the conflict in Ukraine, air superiority and its denial. Details at https://warontherocks.com/2022/06/in-denial-about-denial-why-ukraines-air-success-should-worry-the-west/, accessed 06.11.2023.

[2] N.A.: NATO reporting name: SA-21 Growler.

[3] N.A: The threat posed by the presence of the S-400 systems increased when they were supported by the Russian S-band 48Ya6 "Podlet-K1" all-altitude radar deployed in Belarus. More details at https://static.rusi.org/SR-Russian-Air-War-Ukraine-web-final.pdf , accessed 06.11.2023.

including missile storage containers, launchers, and radars. Testing of the system began in late 1999 or early 2000 at the Kapustin Yar missile range in Astrakhan Region, Russia (Missile Defense Project 2021). In 2017, The Economist considered that "the S-400 is one of the best air-defence systems currently made " (The Economist 2017).

From an organizational point of view, the standard S-400 battery consists of four launchers[4] each with four launch tubes, engagement radar (fire control) systems, surveillance radar target acquisition, and a command center (arranged on a vehicle). In the Russian army, an S-400 battalion (also known as a S-400 division) comprises two batteries, whereas a regiment has two S-400 battalions in its structure (Gady 2018). An S-400 battery with a maximum of 16 long-range missiles or 64 medium-range missiles, or a combination of the two (Dalsjö, Berglund and Jonsson 2019, 54), can deploy in five to ten minutes and supposedly engage up to thirty-six targets simultaneously (Roblin 2018). If one takes into account the number of missiles available for launchers and the national doctrinal provisions (launching two missiles to each target to increase the probability of a hit) (Bronk 2017), a simple calculation can show that a battalion can engage a maximum of 16 targets at the same time with long-range missiles, or 64 targets if only launching medium-range missiles (Dalsjö, Berglund and Jonsson 2019, 54). But the reality of the battlefield will never take into account the calculations on paper.

[4] Transporter Erector Launchers/TELs.

The performance of the S-400 " Triumf " system is mainly determined by the type of missile used and the air and missile defense configuration it is part of. Thus, the 48N6 missile series allows the system to hit aerial targets at ranges up to 250 km (Missile Defense Project 2021). They are also intended for intercepting medium-range ballistic missiles (maximum range of 3,500 km and speed of 4,800 m/s), at a distance between 5 and 60 km and an altitude between 2 and 27 km (Giles 2015, 16). Another series, with two versions with active radar missiles, known as 9M96 and 9M96DM, with short and medium range (40 and 120 km) is intended to be used against tactical aircraft, PGMs[5], and ballistic missile warheads, being the system's option for self-defense and for the protection of any nearby high-value target (Dalsjö, Berglund and Jonsson 2019, 28).

[5] Precision-Guided Munition.

In the year 2021, the 77N6 missile series was in the testing phase and was expected to use hit-to-kill technology to destroy ballistic missiles (Missile Defense Project 2021). One of the system's new missiles is the so-called 40N6, with an estimated operational range of 400 kilometers (248.5 miles) and an altitude of up to 185 kilometers (607,000 feet), being responsible for the often-repeated claim that the S-400 has one of the longest ranges. The missile is reportedly capable of exo-atmospheric interception of intermediate-range ballistic missiles in the final phase of flight (Gady 2016), but there are fears among specialists regarding the radar's ability to support the system to make

the most of the missile's performance (Missile Defense Project 2021)[6].
The system's declaratory ability to use different types of missiles, with distinct missions and particularities, may provide an important feature, namely the ability for the system alone to form a large part of a layered air defense. In this way, the S-400 system is among the most advanced air and missile defense systems available, on parity with the best the west has to offer[7].

The exclusive assessment of a surface-to-air missile system is inappropriate and can highlight at most how it is organized, staffed, or equipped. The discussion about the performance of such a system must have as its starting point its ability to integrate. In order to achieve increased effectiveness, it is thus required that the S-400 " Triumf " system be used as part of an integrated air and missile defense system, otherwise, the whole thing is just a costly and expensive military extravagance (Wilson and Parachini 2020). Based on the 2016 air and missile defense organization of Hmeymim Air Base in Syria, it can be inferred that the Russian military's approach to this concept is aimed at achieving a three-level layered defense, which thus allows the application of the A2/AD concept. Thus, for the mentioned base, the available systems were arranged to achieve a robust and, above all, flexible defense against a varied range of threats. The first layer was provided by the long-range S-400 and S-200VE systems, the second is handled by the medium-range S-300FM Fort-M and Buk-M2E systems, while the last layer integrated the SHORAD[8] Osa-AKM and S-125 Pechora-2M systems. Finally, the Pantsir-S1 systems were considered for the direct defense of the S-400 system (Khodaryonok 2016).

## Vulnerabilities and employment of the S-400 "Triumf" system

It is well known that surface-to-air missile systems are differentiated by a number of constructive and technical or tactical characteristics, just as the situations in which they are used are distinct and different. Thus, there is consensus among military specialists that there is no ground-based air defense system that can be considered *the best*. A system can be valued by the design of which it is part of, by the decisions to use it, or by the level of training of the personnel who serve it.

For the surface-to-air missile systems, there are general vulnerabilities, otherwise characteristic of all systems, which may affect them differently, such as geographical factors (coverage due to mountainous features, the horizon of the earth, weather conditions), dependence on the presence of single surveillance and engagement radar (not always on the same platform), or the possibility of saturating of surveilling and engagement systems. At the same time, there may also be specific vulnerabilities, generated by the

[6] N.A.: The name and some of the characteristics of the missiles used by the S-400 system may be different, depending on the existing sources in the online environment. For example, see https://www.defenceiq.com/air-land-and-sea-defence-services/articles/how-capable-is-the-s-400.
[7] N.A.: Opinion stated by Siemon Wezeman, SIPRI Senior Researcher in *Why do countries want to buy the Russian S-400?*, available at https://www.aljazeera.com/features/2018/10/8/why-do -countries-want-to-buy-the-russian-s-400.
[8] Short range air defense.

high costs of maintenance or operation, the qualification of the personnel, the period of time required for deployment, the increasingly true assumption of operation in a disputed electromagnetic environment or the existence of countermeasures for different types of missiles, etc.

A specific problem for long-range surface-to-air missile systems is the limitation of the surveillance and engagement radar capabilities by the horizon of the earth. Without taking into consideration the possibilities to overcome this obstacle (some examples include the elevation of antennas, integrated work with early warning aircraft, the use of aerostats[9], and the use of systems within a layered defense) the S-400 system, but also other systems in this category, are vulnerable to a low-altitude attack by cruise missiles or drones, which in large numbers can overwhelm the system (Wilson and Parachini 2020). In a situation where the adversary has control of the airspace, this limitation can turn into a major vulnerability, making the defense mission or air and missile defense even more difficult.

The threat of cruise missiles is not the only one. Apart from the classic threats generated by aircraft, attacks by drones, ballistic or cruise missiles, the evolution of stand-off missiles and electronic warfare systems only demonstrates, if anything else, the difficulties faced by air defense, from the concept to demonstrate the effectiveness. Also, in this case, one must be aware of the fact that the long range of action is not a guarantee of success. Missile and drone attacks on oil production facilities in Saudi Arabia in 2019, or Ukraine's drone attacks that disabled Russian S-400 systems, are significant examples of air defenses being defeated with equipment that represents a low percentage of the complex systems cost that make it up and which are difficult to operate efficiently. For example, the S-400 costs approximately $500 million, a Patriot Pac-2 battery costs $1 billion, and a THAAD battery costs about $3 billion (Macias 2018).

One of the most comprehensive assessments of the S-400 system was carried out by the Swedish Defence Research Agency[10] in the *Bursting the Bubble report. Russian A2/AD in the Baltic Sea Region: Capabilities, Countermeasures, and Implications*. Throughout the 116 pages, the authors analyze the Russian A2/AD capabilities in the Baltic Sea region as well as NATO's possible countermeasures, also identifying a series of vulnerabilities and limitations of the S-400 system. Without being considered definitive or exhaustive, these limitations are (Dalsjö, Berglund and Jonsson 2019, 18, 27, 50, 54):

- The effective range against low-flying maneuvering targets is much less than the declared maximum characteristics (400 km), sometimes even up to 20 km for small-sized targets evolving at very low altitudes (nap of the earth). For older Tomahawk cruise missiles, operating in mixed terrain, the effective range is 24–36 km;

[9] N.A.: The online publication Defense Romania presents the opinion of Russian military expert Vladislav Shurygin in the article Exasperated by Ukrainian drone attacks, Russians use balloons to detect waves of UAVs sent by Ukraine, according to which Russian air defense systems are not able to cope of unmanned aerial vehicles of the Ukrainian army that operate at low altitudes. Thus, it is inappropriate to use missile systems that are classically intended to combat aircraft or missiles, to combat the new threats. One solution may be the creation of a defense line, which would include radar balloons, as well as aerial surveillance, warning and communications posts; Details at URL: https://m.defenseromania.ro/exasperati-de-atacurile-dronelor-ukrainene-rusii-folosec-baloane-pentru-pentru-a-detecture-valurile-de-uav-uri-trimise-de-ucraina_624774. html.

[10] Totalförsvarets forskningsinstitut/FOI.

- The limitations of the system in hitting all threats simultaneously, in the situation where they appear in large numbers in a short period of time;
- The existence of a single engagement radar for each battery can be a vulnerability, as taking it out of service will render the entire battery inoperable with the 16 or 64 missiles ready for launch;
- The size of long-range missiles (they are heavy and bulky, weighing about two tons), which means that reloading the launchers after launching them requires extremely valuable time, in the situation of multiple and complex threats;
- General characteristic of the system: it is probably optimized for the interception of ballistic missiles and aircraft considered high-value targets, flying at high altitudes, but intercepting small-sized targets at low altitudes may be an auxiliary function.

Recent history provides examples that demonstrate that surface-to-air missile systems have vulnerabilities and limitations and cannot always guarantee the results desired by military and political leaders. If Russian surface-to-air missile systems have been quite criticized following their recent use, especially in Syria, Armenia, or Ukraine, the Patriot systems take the headlines when they had difficulty in intercepting ballistic missiles in the Gulf War.

The Kremlin decided to deploy an S-400 "Triumf" system to Syria in 2015, a day after a Russian Su-24 Fencer was shot down, which Ankara said it had been using Turkish airspace without authorization (CBS NEWS 2015). Confirming in October 2016 the deployment in Syria of the S-300 and S-400 air defense systems, considered to be of the latest generation, the Kremlin emphasized that it provided air defense of its own air bases against US cruise missiles (Balmforth 2017). Analysis and reactions at the time focused on the formidable theoretical characteristics of the S-400 system and its huge 400 km range, which could cover much of Syria, the eastern Mediterranean, and southern Turkey (Bronk 2017).

But, after an attack with 59 TLAMs[11] that hit the Syrian government air base at Shayrat, on April 7, 2017, where Russian soldiers were also stationed (U.S. Department of Defense 2017), they, consternated, took to social media to find out what happened to the vaunted S-400 systems (Balmforth 2017). It is possible that the main reason why the S-400 system was not used to defend the Shayrat was the fear of failure. There was a real possibility that some of the S-400 missiles had missed their target or were not operating at normal parameters (as of 2017 the system had not reached combat-proven maturity), so that Russia's most important system in Syria could prove to be much less effective, even against fairly easy targets[12], than the huge publicity in the country and beyond assumed (Bronk 2017). At the same time, there was also

[11] Tomahawk Land Attack Missiles.

the assumption, supported by Russian and Western military analysts, that the systems were deployed too far from the Shayrat airbase to be effective against cruise missiles[13]. Under these circumstances, with the exception of destroying an important and hard-to-replace system, its malfunction would deal a huge blow to the reputation of invincibility the Russians had spent years building around the S-400.

Russian military analyst Aleksandr Golts estimated that it is not known whether "the Russian military was not able to intercept the missiles or if it did not want to", taking into account the fact that the Americans complied with the memorandum between Russia and the US-led coalition in Syria on the safe use of airspace, informing the Russians of this two hours before the attack (Balmforth 2017).

Both sides were careful to avoid direct conflict, with the Americans notifying Moscow before the attack, and Russia not engaging Tomahawk missiles as they approached the airbase, most likely on Putin's orders (Roblin 2018). However, there are also opinions according to which ensuring the integrity of Syria's entire airspace was just an overstated statement, aimed at stimulating the sale of weapons and systems deployed in Syria[14], in the case of a cruise missile attack, a perimeter of approximately 40 kilometers can be defended (Bronk 2018)[15].

There were also concerns about the performance of the S-300 and S-400 systems in 2020, also in Syria, when they had difficulty in detecting and engaging, on various occasions, Israeli cruise missiles or effectively countering attacks by Israeli forces (Arif 2021). Also in 2020, the Nagorno-Karabakh conflict represents another example in which the vulnerability of the Armenian air defense was exposed, consisting predominantly of Russian surface-to-air missile systems, against Azeri drones, provided by the Turks and Israelis. During the fighting, Azerbaijan relied on the use of UAS for a wide range of missions, thus demonstrating a technological advantage over the air defense systems of the Armenian forces, which were otherwise designed to combat different threats.

It is important to understand that the myth of Russia's impenetrable air defenses is vital to its efforts to find buyers for these systems because the Russian military relies on foreign investment to ensure the continuity of programs, to develop various types of weapons and weapons systems (Hollings 2023). Even though the S-400 system was designed to combat aircraft and missiles, at distances and heights that vary depending on the type of missile, in Ukraine, Russian leaders have made the decision to use these systems to intercept HIMARS

[12] N.A.: Justin Bronk believes that the cruise missiles used in the April 7, 2017 attack are relatively old missiles that do not have radar-cross section reduction features or sophisticated maneuvering capabilities to avoid interception. See https://www.rusi.org/explore-our-research/publications/rusi-defense-systems/russias-air-defense-challenge-syria.

[13] N.A.: The S-400 systems have been deployed at Russia's Latakia air base and its Tartus naval base, while the Shayrat is more than 75 kilometers away from the city of Tartus and more than 120 kilometers from Latakia. URL: https://www.military.com/defensetech/2018/01/26/russia-deploys-more-s-400-missile-systems-syria.html. Colonel (ret.) Mikhail Khodarenok, a correspondent for Gazeta.ru and an air defense specialist, claimed that the Shayrat air base is located about 200 km from Latakia, thus being at the upper limit of the S-400 system's capabilities. In order for a target to be hit at such a distance, it had to fly at an altitude of 8-9 km, otherwise, the multifunctional radar of the S-400 system could not engage it due to the horizon of the earth. Details at https://jamestown.org/program/russian-air-defense-us-strike-al-shayrat/.

[14] N.A.: Tom Balmforth presents in the article *After U.S. Strikes Syrian Air Base, Russians Ask: 'Where Were Our Vaunted Air Defense Systems?'*, available at https://www.rferl.org/a/weher-was-the-s-300-s-400-missile-defense- systems/28417014.html, the statement of Pavel Felgengauer, a Moscow-based military analyst, regarding the effectiveness of the S-400 system: *All this talk that we have secured the whole of Syrian airspace is artistic whistling.*

[15] N.A.: The effective engagement range of Russian air defense systems deployed in Syria against cruise missiles (flight altitude around 30–100 m) or low-flying aircraft is limited to their radar horizon, which for such targets is about 30-40 km. See https://rusi.org/explore-our-research/publications/commentary/could-russian-s-400s-protect-syria-against-cruise-missiles.

rockets or, much more out of the ordinary, *to bombard* Ukrainian cities (Peck 2023).

Interception of HIMARS rockets cannot be considered unusual, given that modern surface-to-air missile systems are designed to combat a variety of aircraft and missiles. In Ukraine, domestic systems (S-300) or made available to Ukraine (PATRIOT or IRIS-T) were used to combat Kalibr cruise missiles or even Kinzhal missiles, declared to be hypersonic.

If the use of S-400 systems against HIMARS rockets suggests that the Russian military wants to achieve an effective missile defense, using the same systems to bombard Ukrainian cities[16] may demonstrate desperation and the intention to spread terror among the Ukrainian population, or simply show selflessness in fulfilling with any price of the established objectives. Despite the re-tasked air defense missiles, Russia's reconfigured surface-to-air missiles are less accurate than rockets deliberately designed to hit land targets. For example, a 182-kilogram warhead of an S-400 missile may be devastating against an aircraft or other missile, but it is ineffective against ground targets, especially compared to the 900-kilogram warhead of a cruise missile (for example of the Kh-22 missile also of Russian origin) (Peck 2023).

However, it must be understood that the success of an engagement is not so simple to determine, and the experience of the Patriot system during the 1991 Gulf War is instructive in this regard. The US military developed various reports detailing the performance of the Patriot system during *Operation Desert Storm*. According to reports at the time, they had an almost perfect success rate, with General Norman Schwarzkopf initially claiming a 100% success rate for Patriot structures (Werrell 2005, 205), other sources indicating an approximately 96% kill rate for SCUD missiles engaged in Saudi Arabia and Israel (General Accounting Office 1992, 2). Later, the Army revised downwards its estimate, stating that 90% of missiles aimed at Saudi Arabia and 60% of missiles fired at Israel were successfully intercepted (Cotton and Lewis 2020). As additional information became available, the Army again revised its estimate to 80% in Saudi Arabia and 50% in Israel, because in April 1992, following a revised assessment, reports indicated that the Patriot had 70% success in Saudi Arabia and 40% in Israel (General Accounting Office 1992, 2,3). However, when Congress disputed the results, the Army again revised the estimates, claiming that 52% of the missiles the Patriot system engaged were intercepted successfully (Cotton and Lewis 2020). However, Army leadership was very confident that approximately 25 percent of the engagements made by the Patriot systems resulted in the destruction or disabling of the target's warhead. Of these, approximately 9% of Patriot system engagements in *Operation Desert Storm* were supported by tangible evidence that a SCUD missile was destroyed or disabled after

[16] N.A.: The use of Russian systems for firing surface to air missile in ground-to-ground mode is known among specialists in the field. The SA-2 systems had this firing regime (see https://books.google.ro/books?id=xUS8--YFrlYC&q=%22SA-2%22+%22ground-to-ground%22+Serbs&pg=PA261&redir_esc=y#v=snippet&q=%22SA-2%22%20%22ground-to-ground%22%20Serbs&f=false), and in the conflict in Ukraine evidence of the use of the S-300 system in hitting some ground targets located on Ukrainian territory was presented online. Details at https://www.thedrive.com/the-war-zone/russia-now-firing-s-300-surface-to-air-missiles-at-land-targets-in-ukraine-official and https: //naviny.by/rubrics/politic/2011/10/17/ic_articles_112_175478/. The Ukrainians have also used modified versions of the S-200 surface-to-air missile (retired from service for over a decade) against targets behind Russian lines. The first use of this missile for the new missions was in the August 2022 attack on the Novofedorivka airbase near Saki in Crimea. More details at https://breakingdefense.com/2023/09/what-an-s-400-kill-and-a-spec-ops-raid-reveal-about-ukraines-ability-to-hit-russia/

a Patriot missile detonated in its vicinity, with the remaining 16% of engagements lacking such support (General Accounting Office 1992, 3).

The modernization process of the Patriot system seems to be efficient since a recent article shows its perfect effectiveness. Thus, the Patriot battery deployed in Ukraine would have had a 100% percentage of shooting down the 34 Iskander and Kinzhal missiles that Russia launched at Kiev on June 28, 2023, weapons that Moscow once presented as impossible to be shot down by air and missile defenses (Williams 2023).

## Testing the S-400 "Triumf" system

New surface-to-air missile systems that provide air and missile defense may also have led to the widespread assumption that they are as effective as their producers claim. Even if reality most of the time disproves this, one thing is certain. These systems have to work because otherwise there would be no motivation for nations to buy them, at rather high prices. The transfer of interest, both by producers and those interested in acquisition, from the air defense component to the missile defense component and their integrated use, is something natural, as evidenced by recent conflicts. As researchers Shea Cotton and Jeffrey Lewis presented in their analysis for the *Nuclear Threat Initiative*, as of 2020 there were at least twenty-six countries that either possessed or were in the process of acquiring missile defense systems (Cotton and Lewis 2020).

The difficulty of missile defense should not be underestimated. Missile defense technology is not yet within everyone's reach, and recent experiences have shown that threats to it can always arise, many of them unthought of or at least not considered. Integration can be the key element of such a defense, but it can prove to be the most difficult activity and therefore must be well-planned, budgeted, and executed. Despite the criticism of its performance, the S-400 "Triumf" system must be seen as an effective and competitive system, being often characterized by analogy with the PATRIOT system, even if the direct comparison of the Patriot system to the S-400 is like a comparison of the transmissions of two different race cars (Hollings 2023). The difference between the two systems will always be the manner in which they are integrated into the complex concept of combat use.

If building missiles that fly far and at high speed is no longer a challenge, the difficulties of detecting, identifying, and then hitting small, moving, over-the-horizon targets are still formidable. Under these conditions, the way in which air and missile defenses carry out their missions is in itself an inexact science that lends itself to a lack of transparency. In the case of the S-400 system, it is possible that the lack of clarity over the system's testing activity, reflected in the local and international press, was one of the factors that contributed to criticism of the system in general and its combat effectiveness in particular.

Among countries testing or deploying missile defense systems (whether domestic or imported), for the period 1960-2019, 365 distinct engagements were identified from open sources. Of this total, 221 engagements were testing and 144 operational engagements, but it is possible that there are many more tests and operational uses of these systems than could be identified, a quite plausible reason being the lack of transparency regarding these activities (Cotton and Lewis 2020). The lack of transparency can be understood as a practice at the global level, if the issue is not analysed strictly militarily, because:

- The success of the tests is based on the use of interceptors in almost ideal conditions, and the favorable interpretation of the results can ensure the necessary elements for the extension of a program. At the same time, the overstatement of the results of some tests must also be seen through the lens of potential gain;
- Most of the time the purpose of the test is unknown, so the simple launching or activity of an interceptor can be a success in itself, even if it missed the target;
- Missile defense tests are expensive, and a possible failure would displease the political class. It must be understood that nothing is cheap when it comes to missile defense, except talk, and a capable system is not built by skipping steps or taking shortcuts (Mosher 2000).

Regarding the S-400 "Triumf" system, open sources are quite stingy regarding the information on its testing and use. While not alone in doing so, Russia has issued sweeping statements about the S-400's success, even though there are few public reports of individual tests of the system. According to Russian sources, the S-400 system was tested a total of 32 times in six combat exercises with very good results, which can be quite misleading (Hollings 2022). During these tests, Russian forces launched an unknown number of interceptors, intercepting an unknown number of targets with unknown characteristics. Furthermore, Russia has informed state media that 100% of intercept attempts of the S-400 system have been successful (Cotton and Lewis 2020).

If we take into account the limited number of reports on the S-400 system tests and the fact that experts in the field believe that only successful tests have been disclosed, then it can be suggested that Russia is hiding most of its development tests or other failed intercepts. The assumption that the system is infallible, fully developed, or that it requires no further upgrades is completely false.

Russia's opacity regarding the results of the S-400 program, during tests or the few situations in which it was in real combat conditions, did not prevent other countries from expressing their interest and even acquiring this system. However, assessments and opinions by experts from various countries, regarding the development and use of the S-400 system, led to two conclusions, which cannot be reached only with

the help of intuition. First, the system is not as capable as it is often perceived to be, and second, it is, however, among the most capable air defense systems in use today (Hollings 2022). Results of the S-400 system testing are provided to the public opinion and by some states that bought this system. Thus, on October 16, 2020, Turkey conducted the first real test of its S-400 system deployed in the northern region of the country in Sinop, by launching three missiles, which, according to a defense industry source, all successfully hit the targets designated. Turkey agreed to purchase the S-400 system from Russia in 2017 with the first batteries being delivered in July 2019 (Dahlgren 2020).

In an assessment that can be considered one-sided, the Americans are more transparent when it comes to missile defense tests conducted. However, it should not be left unnoticed that even their reports provide only superficial details of most tests (Cotton and Lewis 2020). However, the true test of the effectiveness of an air and missile defense system is its use in conflict, and despite their global deployment, missile defenses have only been used in isolation with rather controversial results.

## Conclusions

Regardless of the surface-to-air missile system in question, its strengths and vulnerabilities are technical, financial, or human, and it is only as capable as the integrated air defense which it pertains to allows it to be. The full costs and complexity of such a system warrant a systematic analysis of the full range of military, diplomatic, and financial trade-offs. And the S-400 "Triumf" system cannot be excluded from this equation.

Criticized, blamed, or praised, the S-400 "Triumf" system is currently one of the most controversial surface-to-air missile systems in the world because it is constantly under the scrutiny of specialists, and any news about it is examined on all sides. Perhaps underused in conflicts and with uncertain or disappointing results, the system continues to be analysed from all angles to identify vulnerabilities, limitations, and advantages, with its developers committed to demonstrating that it really lives up to its promises and commitments. Otherwise, it is just another surface-to-air missile system of Eastern origin.

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