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A Roof Over Europe? Ground-Based Air Defence After the *Zeitenwende*

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Russia's full-scale invasion of Ukraine in February 2022 – which German Federal Chancellor Olaf Scholz said marked a “*Zeitenwende*” or historical turning point – and the ongoing war since have seen massive use of missiles, revealing considerable gaps in Europe's defences against aerial attacks. This has generated political momentum to strengthen European capabilities for air and missile defence. With the European Sky Shield Initiative, Germany has taken on a leading role in this area. But while the coordinated procurement of new air defence systems is urgent, it is not sufficient in itself to counter the evolving threat environment.

In the early hours of 24 February 2022, Russia's armed forces fired more than 160 missiles at targets in Ukraine. This opening salvo was primarily intended to neutralise Ukraine's air defences so that the Russian air force could gain control of the airspace and support the advance of ground forces on Kyiv and other sections of the front. Another aim was to demonstrate the capabilities of Russia's precision weaponry to break the Ukrainian armed forces' and society's will to fight back, and to paralyse Ukraine's leadership. The intended message: Resistance is futile.

Since then, Russia has deployed thousands more drones, ballistic and cruise missiles against Ukraine. These strikes also left their mark on Germany, as politicians and the public realised that their country, too, lacked protection against such airborne threats. The Bundeswehr's capabilities for protecting densely populated areas or even just high-value targets such as critical infrastructure from enemy fire were also more limited than most people – aside from experts in the field – had assumed. As a result of the shock that Chancellor Olaf Scholz came to call “*Zeitenwende*”, the issue of air and missile defence took centre stage in the German government's efforts to strengthen the Bundeswehr and its military support for Ukraine.

In the third year of Russia's war against Ukraine, the issue is as relevant and urgent as ever. Due to the transfer of various air defence systems to Ukraine, the Bundeswehr's materiel situation today is even more dire than it was at the beginning of 2022. At the same time, the massive use of projectiles, missiles and aircraft by both sides – and their efforts to counter them – have produced new insights on the use and effectiveness, benefits and limitations of modern air and missile defence systems and operational concepts. These need to be evaluated. This paper will therefore first explain the conceptual and technical foundations of ground-based air defence. The frame of reference is the Bundeswehr as part of the NATO Alliance. Subsequently, it will offer initial observations about countering airborne threats from Russia's war against Ukraine. The European Sky Shield Initiative, its components and the international reactions will also be contextualised against this backdrop. The paper concludes with a discussion of NATO's plans for integrated air and missile defence after the *Zeitenwende*.

The basics of ground-based air defence

The Bundeswehr's core mission of national and collective defence includes responsibility for maintaining the security of Germany's airspace and the airspace in theatres of operations. In peacetime, the Bundeswehr's control and reporting centres surveil the German airspace. In addition, the German Air Force keeps two quick reaction alert elements of Eurofighter combat aircraft on permanent standby. Among other missions, they are tasked with intercepting aircraft with which no radio contact can be established and attempting to contact them using visual signals in order to rule out the possibility of terrorist attacks or other dangerous situations. Since 2005, the Bundeswehr has also been regularly participating in the NATO Baltic Air Policing mission to help Estonia, Latvia and Lithuania, which do not have air forces of their own, to protect their sovereign airspaces.

In the event of a conflict, both defensive and offensive operations and measures would be employed in air defence to combat enemy air assets and to gain and maintain control of the airspace. In this context, the German Air Force would shoulder most of the responsibility, through both airborne counterair operations with combat aircraft and ground-based air defence with weapon systems on land. However, the Army, the Navy and the new Cyber and Information Domain Service also contribute capabilities for protecting or supporting to protect mobile forces and fixed assets from airborne threats, for example, through special operations forces, sea-based surface-to-air missiles or jammers for electronic warfare.

The threat spectrum that air defence has to handle is increasingly complex and now includes smaller objects such as artillery shells, rockets and drones, as well as helicopters, fighter aircraft, ballistic and cruise missiles. No air defence system can counter all possible threats equally effectively (and efficiently). Different weapon systems have to be used depending on the size of the area and the type of unit or asset to be protected, as well as the type of threat. Any one air defence system (or fire unit) combines sensors, command and control assets, and air defence guns or interceptor-missile launchers. The Bundeswehr's air defence capabilities are part of NATO's *Integrated Air and Missile Defence* (IAMD), which provides the political and operational framework for Allied air defence and is intended to ensure the availability of a common airspace situational picture for the entire NATO territory.

Ground-based air defence includes all land-based assets for threat detection and tracking, command, control and communications, and engagement. Each system is optimised for certain threats and ranges: short and very short range (up to an altitude of 6 km/distance of 15 km), the lower layer (up to 35 km/100 km) and the upper layer (more than 35 km/100 km). A system for defending against low-flying drones, for example, is unable to also engage medium-range ballistic missiles.¹ The latter reach the peak of their trajectory at an altitude of more than 100 km and move at several times the speed of sound during their target approach. The sensors of a system designed to counter drones could not detect such a missile, and its gun or interceptor missile would not be able to engage them. In order to counter a multitude of different threats, various air defence systems must be combined. Additionally, geographical features affect the effectiveness of ground-based systems. Mountains and valleys cause gaps in radar coverage that aircraft or cruise missiles with terrain-referenced navigation could exploit. This is one reason for why airborne and satellite-based sensors are becoming increasingly important for ground-based air defence.

Integrated air and missile defence is a key element of NATO's deterrence and defence posture, along with nuclear and conventional capabilities, supplemented by space and cyber capabilities. Air defence achieves military-operational effects by protecting countries' own forces and assets, such as airfields or ports, in order to maintain their effectiveness in a conflict over time and facilitate the concentration of forces for manoeuvre operations. From a political-strategic standpoint, air defence complicates potential

¹ The US Department of Defense's Missile Defense Agency distinguishes between *short-range* ballistic missiles with a range of 300 to 1,000 km, *medium-range* ballistic missiles with a range of 1,000 to 3,000 km, *intermediate-range* ballistic missiles with a range of 3,000 to 5,500 km and *intercontinental-range* ballistic missiles with a range of more than 5,500 km.

adversaries' attack planning and helps to minimise the damage caused by their attacks – whether on military or civilian targets. In this way, it counteracts conventional and nuclear blackmail attempts, buys time and enhances flexibility for decisionmakers, and thereby improves escalation management options. At the same time, air defence is a dynamic interaction: measures taken by one side are usually followed by the other's countermeasures.² Fully effective protection of the entire NATO territory at all times is technically infeasible and prohibitively expensive. This is another reason for why it is essential not to neglect offensive capabilities, such as standoff precision weapons, which can engage enemy strike assets at distances sometimes exceeding 1,000 km.³ The prioritisation of ground-based air defence since the *Zeitenwende* shows how inadequate Germany's capabilities in this area were before – in terms of both quality and quantity – and still are, despite the initiation of various procurement processes. This shortcoming seems particularly drastic when existing capabilities are measured against the realities of the war against Ukraine, in which Russia has fired thousands of larger missiles of various kinds since February 2022 and Ukraine has fired many hundreds of interceptor missiles.

Observations from Russia's war against Ukraine

At the start of Russia's full-scale invasion, the Ukrainian armed forces operated Soviet-era air defence systems, including several variants of the S-300 system for longer ranges and the medium-range system Buk, as well as short-range air defence guns and missile systems. Despite intense attacks on Ukrainian airfields and air defence sites during the first hours of the war, Russian forces failed to neutralise Ukraine's air defence assets and consequently were unable to establish air superiority. Since then, the air warfare has been characterised by innovations and adaptations on both sides, which are determined by the availability of new weapon systems and the search for asymmetric advantages.⁴ Ukraine's air defence is suffering from attrition. Early on, several Central and Eastern European countries provided Ukraine with Soviet-produced systems, spare parts, and ammunition from their own stocks to close gaps. In the medium term, however, it became necessary to supply and provide training for modern NATO standard systems to ensure long-term supply and replenishment through Western industry. Because these systems often come with more effective radars and interceptor missiles than comparable Soviet or Russian systems, Ukraine's air defence capabilities have also experienced a qualitative upgrade.

Stinger shoulder-fired surface-to-air missiles were among the first systems provided by the West. They reached Ukraine just a few days after the beginning of the full-scale invasion. With these and other mobile systems, the Ukrainian armed forces successfully engaged some low-flying Russian combat aircraft. From then on, Russia's air force refrained from operating piloted aircraft too close to the ground. German *Gepard* self-propelled armoured air defence gun systems followed from July 2022. These proved to be particularly effective against Russian drones and cruise missiles. In October 2022, Ukraine received the first IRIS-T SLM surface-to-air missile system. Originally slated for Egypt, at the request of the German government Cairo agreed to it being diverted to Ukraine, however. Following Russian bombardment of civilian energy infrastructure in the first winter of the war, Germany, the Netherlands and the United States supplied Ukraine with Patriot systems in spring 2023. With Patriot, Ukraine has since managed to intercept even modern Russian missiles such as the Kinzhal hypersonic air-to-surface missile or the Zircon hypersonic cruise missile.

In spring 2024, decades-old Russian glide bombs caused problems for Ukraine as these were being dropped outside the range of Ukraine's air defence systems or from inside Russian airspace. Russia is believed to have tens of thousands of these bombs in its stores. For that reason, a strategy that aims at engaging every single glide bomb is doomed to fail. Instead, the bombers that launch them or their airfields would have to be targeted. Until May 2024, however, Ukraine was largely prohibited from using weapons of Western origin

² Calcara/Gilli/Gilli/Marchetti/Zaccagnini (2022): [Why Drones Have Not Revolutionized War. The Enduring Hider-Finder Competition in Air Warfare](#), *International Security* 46 (4), p. 130-171.

³ Loss/Mehrer (2023): Striking absence: [Europe's missile gap and how to close it](#). Berlin: European Council on Foreign Relations.

⁴ Bronk/Reynolds/Watling (2022): [The Russian Air War and Ukrainian Requirements for Air Defence](#). London: Royal United Services Institute.

against targets inside Russian territory or airspace. While these restrictions have since been relaxed, at least for border regions, many of the aforementioned airfields still remained out of reach. For large-scale attacks, Russia's armed forces also combine different types of strike systems to overcome Ukraine's defences with sheer mass and complex flight patterns. In addition, frontline forces face an onslaught of Russian attack drones. Jammers to block the drones' wireless communication are in short supply.

On the whole, Ukraine's air defences achieve impressive interception rates. Nevertheless, the limited availability of systems and interceptor missiles allows Russia to continue devastating attacks on Ukrainian cities, critical infrastructure, and military targets. Comparison with the successful defence against the some 300 missiles in Iran's attack on Israel in April 2024 illustrates the gaps in Ukraine's less deep and broad ground-based air defences.⁵ Shortcomings in sensors and command and control capabilities as well as the lack of combat aircraft for counterair operations have also prevented better protection against Russian aerial attacks to date. A capability coalition for integrated air and missile defence under the leadership of Germany and France aims to plug these holes over the medium to long term.

Capability gaps and the European Sky Shield Initiative

During the Cold War, the airspace over West Germany was considered to be the most densely defended area of the entire NATO territory. When the bloc confrontation ended, the Bundeswehr's ground-based air defence was massively downsized.⁶ The Army Air Defence Corps (*Heeresflugabwehrtruppe*) was eventually disbanded, and mobile weapon systems such as the *Gepard* self-propelled armoured air defence gun system and the Roland air defence surface-to-air missile system were withdrawn from service. At the beginning of 2022, the Bundeswehr operated twelve Patriot fire units (of the 36 it had in 1990) for countering air threats ranging of up to 1,000 km and at altitudes of up to 35 km, along with a few *Ozelot* mobile weapon platforms with Stinger missiles for defence against threats at a maximum distance of 6 km. The latter are to be taken out of service in 2026. In 2009, the Bundeswehr procured two MANTIS stationary weapon systems to protect bases from rockets, as well as artillery and mortar shells. Since then, three Patriot fire units (consisting of radar, fire control station, and multiple launchers) and some additional Patriot launchers with ammunition as well as 500 Stinger surface-to-air missiles have been provided to Ukraine from Bundeswehr stocks. Moreover, Slovakia received the two MANTIS systems.

Gaps in Germany's ground-based air defences were well known even before the *Zeitenwende*, and possible solutions to close them were largely identified. The 100-billion-euro special fund for the Bundeswehr, announced on 27 February 2022 after the shock of the full-scale invasion and adopted the following June, made available the money to procure these. Speaking at Charles University in Prague on 29 August 2022, Chancellor Scholz announced the intention to open these German procurement projects to European partners in order to reduce costs and achieve synergy effects in logistics and training. In September 2022, initial talks were held and a draft memorandum of understanding for a European Sky Shield Initiative (ESSI) was presented. Fifteen European countries signed up to it at the margins of the 13 October 2022 NATO Defence Ministerial. As of July 2024, a total of 21 countries have joined the initiative, 13 of which have already concluded additional agreements with Germany as a basis for potential joint procurement of systems.

The initiative focuses on joint procurement of air defence systems (IRIS-T SLM and Skyranger) and ammunition (such as interceptor missiles for the Patriot system). IRIS-T SLM is designed to counter threats in the lower part of the lower layer (below Patriot) and at short range. The Bundeswehr is planning to introduce it in mid-2025. In addition, the memorandum describes a common interest in systems for very-short-range

⁵ The comparison refers solely to the number, diversity, and integration of different air defence systems. Beyond these aspects, differences in the regional geography of the theatres, the warning times for the attacks, the political intentions of the attackers, and other factors limit the extent to which the two cases should be compared.

⁶Hartung (2022): *Ein Dach über Europa. Politische Symbolik und militärische Relevanz der deutschen bodengebundenen Luftverteidigung 1990 bis 2014*. (Berlin/Boston: De Gruyter).

protection. In this area, the Bundeswehr is procuring the Skyranger 30 air defence gun system based on the Boxer wheeled armoured fighting vehicle. Other ESSI countries want to use the Skyranger turret on different platforms; Hungary, for example, plans to use it on the Lynx tracked vehicle. In addition, the Bundeswehr plans to procure a mobile surface-to-air missile system with the short-range IRIS-T SLS missile, also based on the Boxer. This would ensure protection of ground forces in land operations with mobile air defence gun and missile systems, similar to how the *Gepard* and *Roland* systems were being employed at the end of the Cold War. With the recently announced reconstitution of the Army Air Defence Corps by 2028, these capabilities will once again be pooled in one branch. Criticism of these pillars of ESSI was primarily directed against Germany's decision to procure national or non-European systems instead of focusing on other European solutions as agreed by the EU member states as a common objective in documents such as the Versailles Declaration of March 2022. This ambition to strengthen European sovereignty seems to have been set aside in favour of focusing on the urgent aim of quickly closing the gaps in air defence.

Germany's procurement of the Arrow 3 missile defence system

Germany's decision to procure the US-Israeli Arrow weapon system for territorial missile defence received particular attention. The Arrow 3 interceptor is supposed to enable the Bundeswehr to counter long-range threats such as medium and intermediate-range ballistic missiles, which can travel several thousand kilometres. The interceptor is designed to destroy such missiles above Earth's atmosphere, at an altitude of about 100 km, with a direct hit. However, aerodynamic drag at lower altitudes and other factors limit its utility within the Earth's atmosphere. The Arrow system's *Green Pine* radar significantly enhances the Bundeswehr's capabilities for persistent 360-degree airspace surveillance. In April 2024, Arrow 3 demonstrated its abilities against Iranian medium-range ballistic missiles approaching Israel.

Critics of this decision point out that Russia does not currently have any such weapons in its arsenal, and see a need for further clarification.⁷ Russia's short-range ballistic missiles and cruise missiles and even the Kinzhal air-to-surface missile do not reach the exoatmospheric altitudes for which Arrow 3 is designed, while Russian intercontinental ballistic missiles move outside of Arrow 3's intercept range. In any case, these intercontinental ballistic missiles are intended for strategic deterrence against other nuclear powers, primarily the United States, and not for limited employment in regional conflict scenarios.⁸ Despite Russia's extensive modernisation efforts in other areas of its missile arsenal and one or the other allusion by Russian leaders, no information points to the development of new medium or intermediate-range ballistic missiles or a revival of previously discontinued projects at this time.

To date, the German government has not publicly presented a requirements analysis for the Arrow procurement that refers to concrete threats. Rather, the requirement seems to be derived from the capability gap in territorial missile defence and from potential future threats, including the proliferation of missile technologies. In recent months, for example, Russia has received hundreds of short-range ballistic missiles from North Korea and Iran. Both also operate weapon systems with even longer ranges that they could provide to Russia or other potential adversaries of NATO. The Houthi rebels in Yemen, for instance, have received several long-range systems from Iran in recent years, including *medium-range* missiles, and repeatedly fired them. Even beyond these countries, a growing number of actors will likely be able to develop such systems on their own in the future, while the international arms-control architecture intended to curtail such efforts is eroding.

⁷ Wachs (2023): [Russian Missiles and the European Sky Shield Initiative. German plans to strengthen air and missile defence in the current threat environment](#). Berlin: German Institute for International and Security Affairs (SWP).

⁸ Kofman/Fink/Edmonds (2020): [Russian Strategy for Escalation Management: Evolution of Key Concepts](#). Arlington, VA: Center for Naval Analyses.

Nevertheless, it remains to be seen whether Germany's Arrow procurement presents an efficient use of resources to strengthen the deterrence and defence posture of NATO. For four billion euro (or some part of that, if, for example, Germany had procured only the *Green Pine* radar), the Federal Republic could also have acquired other air defence systems or offensive capabilities to deter adversaries from attacking in the first place due to the threat of retaliation. While Arrow is often described as part of ESSI, it is a purely national procurement project without participation by other European partners. It is not initially intended for integration into the NATO IAMD structures either.

Outlook for NATO's Integrated Air and Missile Defence

Current efforts to boost NATO's capabilities largely go back to the defence planning cycles after 2014.⁹ Even then, integrated air and missile defence was already seen as a priority for the Alliance's deterrence and defence posture. With the regional and domain-specific defence plans that the NATO summits in Madrid, Vilnius and Washington, D.C. have called for and then adopted since 2022, the level of ambition across all capabilities increased further, but especially for air and missile defence.¹⁰ For the Bundeswehr, this means that the various procurement projects initiated to date will not suffice. Further increases are to be expected and must be backed by appropriate financial and personnel resources and industrial production capacity.

In addition to procuring new air and missile defence systems, European NATO Allies must pay close attention to intelligence, surveillance, and reconnaissance as well as command, control, and communications capabilities, and their networking and integration. One reason why Patriot and IRIS-T SLM achieve such high intercept rates in Ukraine is that close integration of the two systems had already been aimed for in the development phase of the latter, meaning that sensor data can easily be shared between the two. NATO, too, should place higher priority on sensor fusion and operational integration of different air defence systems. The United States still contributes the bulk of strategic enablers and force multipliers in the Alliance. As America shifts its strategic focus towards the Indo-Pacific, these resources could become less available for Europe in the medium term – or even very suddenly in the event of an acute crisis over Taiwan, for example. The same is true of the aforementioned stand-off precision weapons that form part of NATO's mix of capabilities.

Closing all these gaps will require creative approaches. The Prime Ministers of Greece and Poland recently called for the European Union to play a bigger role in building up European air and missile defences, one that goes beyond supporting individual development projects and could include mobilising additional financial resources. Europeans could also consider procurement frameworks that distinguish between procuring countries and user countries to share the purchasing and operating costs among larger and smaller NATO members. The European NATO countries' Framework Nations Concept could offer a starting point for such efforts. ESSI is setting the right course, despite the sometimes-harsh criticism it has faced from the very beginning, for example from French President Macron in 2023 for lacking a proper strategic foundation. Since then, the German government has placed greater emphasis on the role of nuclear deterrence and conventional long-range strike capabilities to take this criticism into account. Germany, France, the UK, Italy and Poland, in various coalitions, have begun working towards developing and deploying standoff precision weapons – does this signal the start of another European capability initiative? In light of the challenges, every effort is needed to strengthen the European pillar of NATO and ground-based air defence as a roof over Europe.

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This article reflects the authors' personal opinions.*

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⁹ Monaghan/Kjellström Elgin/Bjerg Moller (2024): [Understanding NATO's Concept for Deterrence and Defense of the Euro-Atlantic Area](#). Washington, D.C.: Center for Strategic and Budgetary Assessments.

¹⁰ Cakirozer (2024): [NATO's Evolving Air and Missile Defence Posture](#). Brussels: NATO Parliamentary Assembly (Draft 048 DSC 24 E).