CHAPTER THREE

European Integrated Air and Missile Defence: Slow Progress

From 1991 until February 2022, Europe faced no peer-level threat requiring overarching air and missile defence. But Moscow's full-scale invasion of Ukraine, which has included ballistic- and cruise-missile strikes and attacks by combat aircraft, has cast in stark relief Europe's need to rebuild a comprehensive capability to monitor and defend its airspace and to deny an aggressor air superiority.

Air defence was a critical role for NATO during the Cold War, with a large proportion of the Alliance's tactical combat aircraft allocated to the defensive counter-air task. These aircraft were complemented by multiple surface-to-air missile (SAM) belts and air-defence radars. The need for NATO to be able to defend against the peer-level air threat fell into abeyance with the Warsaw Pact's dissolution in July 1991 and the Soviet Union's collapse by December that year.

Russia's military performance in Ukraine has been marked by failures, even amid grinding incremental gains. Western analysts did not expect the Russian air force (VVS) to match NATO standards of operation, but many were still surprised by its limited effectiveness, especially considering post-2008 modernisation and its apparent operational success in Syria.[1] However, this should not be a cause for European complacency. Moscow's Aerospace Forces (VKS), of which the VVS is part, remain largely intact. The war, furthermore, has provided the VVS with harsh operational lessons and the service has shown the capacity to learn and adapt.

NATO defence ministers endorsed the Alliance's integrated air and missile defence (IAMD) policy at the Defence Ministerial meeting in February 2025.[2] This document noted: 'Ensuring the volume and quality of defensive systems against all range[s] of air and missile threats is a critical factor for ensuring the strength and durability of NATO IAMD'.[3] The need to address the issue of volume was underscored by NATO Secretary General Mark Rutte in June 2025 when he declared a requirement to increase Alliance IAMD by 400%.[4]

While he neither elaborated on what the increase would entail, nor assigned a time frame, his comments reflect the recognition within NATO that air and missile defence has been an area of comparative neglect and an underinvestment that is no longer acceptable.

Key Takeaways

EUROPEAN IAMD GAPS

Europe lacks adequate IAMD across almost the entire threat spectrum. Capable systems, from point defence to short-, medium- and long-range defence, are in service, but most are not available in the required volumes.

GREATER COORDINATION NEEDED

Europe has a well-developed guided-weapons defence-technology base, covering many of the elements required for IAMD. However, national priorities, combined with mixed signalling at the European level, risks duplication in areas such as ballistic and hypersonic cruise missiles and defence against hypersonic glide vehicles.

RELIANCE ON THE US

European terminal-phase missile-defence capabilities rely mainly on the US either in the form of US-made missile-defence systems operated by national militaries, or US systems deployed to Europe, principally the *Patriot* system. Moreover, as of mid-2025, exo-atmospheric mid-course interception capabilities in Europe are provided solely by the US.

NEW NATO TARGETS: LIKELY HARD TO REACH

NATO's latest capability targets include the ambition to quadruple Alliance air and missile defence. However, even if this ambitious objective were to be achieved, it may still fall short of meeting NATO's European IAMD requirements.

RUSSIA: LEARNING LESSONS FROM THE WAR

Russia's full-scale invasion of Ukraine has degraded Russia's ground forces but has provided them – and the air force – with an operational testing environment. While systems and tactics have often been found wanting, Russian air and ground forces have adapted. As a result, they continue to pose a threat to European NATO forces.

A Ukrainian soldier mans a *Gepard* self-propelled anti-aircraft gun, 23 November 2023. Credit: Kostya Liberov/Libkos/Getty Images

Air superiority, the ability to operate with relative freedom and deny that to an opponent, is fundamental to any air campaign. Russia has failed to achieve this in Ukraine. Ukraine's air defence remains operationally effective and has forced the VVS to adapt. Without air superiority, the VVS has turned to low-cost stand-off weapons to reduce the risk of tactical-combat-aircraft losses, with fighter ground-attack aircraft largely restricted to flying only above Russian-held territory. Russian aircraft have occasionally been operated near or directly over the front line, typically during periods of reduced Ukrainian air-defence coverage, but have largely been absent from Ukrainian-defended airspace.

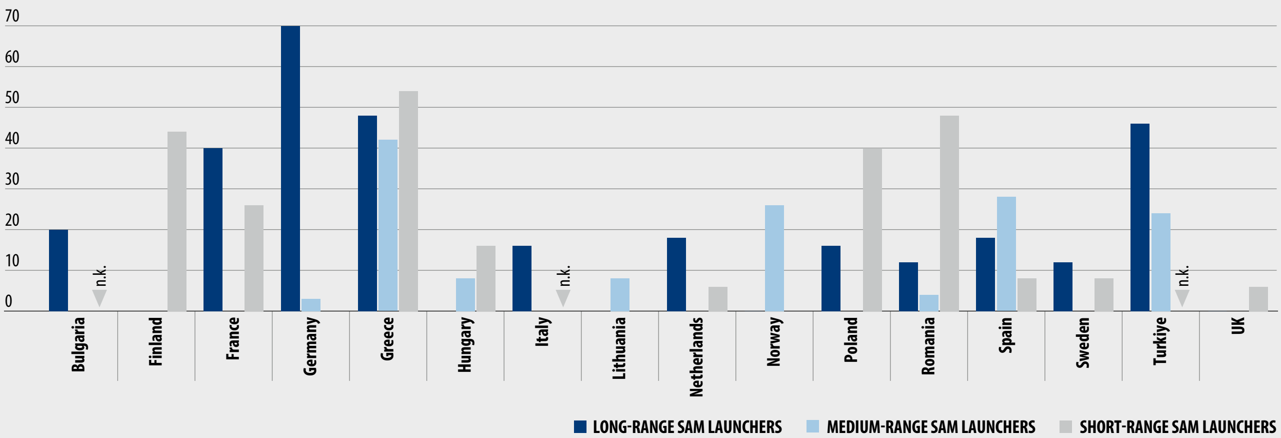
European air defences in 2025

European air defences today present a mixed picture. NATO air forces operate multi-role fighter aircraft and possess a variety of domestically produced and US-manufactured long- and medium-range SAM systems (see Figure 3.1). The capability to defend against SRBMs relies predominantly on US-made platforms. These capabilities, however, are not matched by capacity. Current European stockpiles of SAMs and air-to-air missiles (AAMs) are inadequate for high-intensity warfare. Nor is the continent's industrial base capable of scaling production fast enough to meet increased demand.

There are gaps in almost all European inventories at the short- and very short-range level. These vulnerabilities leave Europeans poorly prepared for the kind of one-way attack (OWA) uninhabited aerial vehicle (UAV) and first-person view (FPV) warfare seen in Ukraine.

While many governments have identified air and missile defence as a capability gap, there are differences on how best to address it. The core tension lies between two competing approaches. One prioritises the rapid acquisition of off-the-shelf systems, largely from the United States and, to a lesser extent, Israel. The other seeks to develop European autonomy in air defence, favouring domestically produced systems. These approaches are exemplified in the German-led European Sky Shield Initiative (ESSI), which aims to close air-defence gaps with off-the-shelf procurement of systems such as the German *Skyranger* and IRIS-T, the US *Patriot* and the Israeli *Arrow* 3. France has criticised this approach, advocating instead for a focus on European-made systems – particularly the Franco-Italian SAMP/T – as part of a broader push for defence-industrial sovereignty.

Figure 3.1: **Surface-to-air missile (SAM) launchers in service with selected European NATO members**



Sources: IISS, Military Balance+, milbalplus.iiss.org

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Russia's air and missile threat

The war in Ukraine has provided insight into the breadth of Russian systems that NATO air defence will need to address. These range from combat aircraft, ballistic and aero-ballistic missiles and cruise missiles to low-cost one-way attack (OWA) uninhabited aerial vehicles (UAVs), and at the tactical level, first-person view (FPV) UAVs (see Map 3.1).

Russia's tactical and long-range aviation forces were involved from the start of its invasion. In the initial stages, VVS tactical fighter ground-attack aircraft operated deep inside Ukrainian airspace, while bomber aircraft were used mainly as cruise-missile launch platforms. Tactical-aircraft losses, however, resulted in the VVS operating its fighter ground-attack aircraft in an increasingly conservative manner, remaining for the most part within Russian-controlled airspace. From early 2023, Russia introduced low-cost glide bombs to supplement its tactical air-to-surface missile inventory.[5] The glide-bomb kits allowed aircraft to be operated beyond the engagement envelope of most Ukrainian ground-based air defence. The use of these weapons increased over time. Approximately 40,000 kits were reportedly produced in 2024 and a further 70,000 ordered for 2025.[6] Ukraine has no air-defence system able to counter them at scale.

Russia has used bomber aircraft, primarily the Tupolev Tu-95MS *Bear* H, to deliver land-attack cruise missiles (LACMs) from the outset of the war. The Tu-95MS has been the primary launch platform for the Raduga Kh-101 (RS-AS-23A *Kodiak*) cruise missile, while the Tu-22M3 *Backfire* C has been used with the Raduga Kh-22 (RS-AS-4 *Kitchen*) and Raduga Kh-32 (RS-AS-4A mod *Kitchen*). The ship- and submarine-launched Novator 3M14 *Kalibr* (RS-SS-N-30A *Sagaris*) and the ground-launched Novator 9M728 (RS-SSC-7 *Southpaw*) and 9M729 (RS-SSC-8 *Screwdriver*) LACMs have also been employed, most often the 3M14. Primary targets for cruise-missile strikes have included Ukrainian military facilities, critical infrastructure and defence-industrial sites.

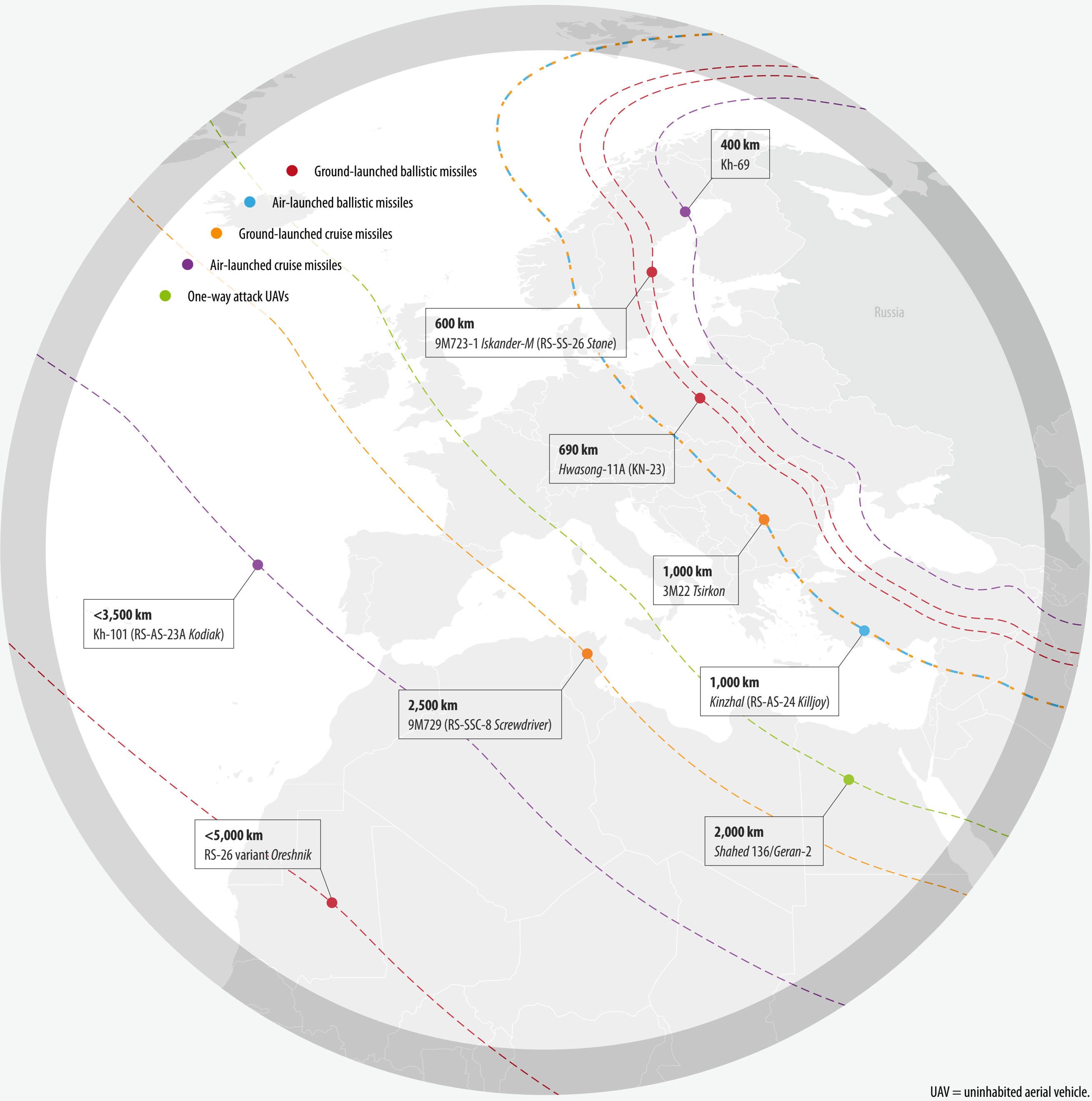
Russian forces have also employed the *Iskander*-M system's 9M723 and 9M723-1 (RS-SS-26 *Stone*) short-range ballistic missiles (SRBMs) against fixed targets, in a manner similar to cruise missiles, and also for engaging time-critical, high-value targets such as mobile air-defence systems. Ukrainian officials have indicated that Russia may have improved its ability to implement such strikes more quickly.[7] An air-launched variant of the 9M723, the *Kinzhal* (RS-AS-24 *Killjoy*), has also been employed sporadically.

The war in Ukraine has marked the first use of Russia's conventionally armed intermediate-range missile, the *Oreshnik*, probably a variant of the RS-26 *Rubezh* (RS-SS-X-28).[8] The *Oreshnik* is fitted with multiple submunitions rather than a unitary warhead. Only a small number have so far been manufactured, likely from the test programme. The 3M22 *Tsirkon* (RS-SS-N-X-33) naval missile has also been tested against targets in Ukraine. Designed as an anti-ship weapon, the 3M22 also has a secondary land-attack capability.

Moscow has also turned to OWA UAVs to supplement and support its land-attack capability. By 2022, Russia had begun importing Iranian-made *Shahed* 136 OWA UAVs, reportedly with a range of up to 2,000 kilometres. The initial deliveries were followed by technology transfers and the establishment of two domestic production lines, where the system is produced under the local designation *Geran*-2.[9] As of May 2025, Russia was reportedly manufacturing up to 2,700 units per month.[10] The country, furthermore, has expanded its investment in tactical loitering munitions, particularly

Aftermath of a Russian missile strike in Kyiv, Ukraine, 17 June 2025.
Credit: Oleksandr Gusev/Global Images Ukraine via Getty Images

Map 3.1: **Approximate ranges of selected Russian long-range strike systems (from mainland Russia)**



UAV = uninhabited aerial vehicle.

Source: IISS analysis

the ZALA *Lancet*. By January 2025, Russian sources claimed that over 2,800 *Lancet*s had been used in Ukraine.[11] Beyond increasing output, Russia has refined both the operational tactics and underlying technologies of these systems. It has introduced airborne relays to extend the *Lancet*'s range beyond typical line-of-sight constraints, enhancing its utility in deeper strikes.[12]

Arguably the most consequential development in UAV use has occurred at the short-range level, driven by the mass adoption of FPV UAVs. Assembled from commercially available components, FPV systems are cheap, typically costing only a few hundred US dollars, and are procured in vast quantities. Russia reportedly produced over 1.5 million UAVs in 2024, the majority of them FPVs.[13] In 2025, it is reportedly targeting the production of two million FPVs alone.[14] Despite their vulnerability to electronic warfare, weather conditions, and low individual hit rates, the scale of deployment has made these systems significant. By 2025, FPVs had surpassed artillery as the primary cause of front-line casualties.[15]

Medium- and long-range air defences

Long-range systems remain key components of IAMD architectures, given the ability to engage targets at extended ranges and to cover large areas. In Ukraine, these systems have been used to intercept OWA UAVs and cruise missiles, as well as crewed aircraft.

In Europe, long-range air defence is largely provided by the *Patriot* system, which the US has exported to Germany, Greece, the Netherlands, Poland, Romania, Spain and Sweden. Some of these systems in turn have been transferred to Ukraine by Germany, the Netherlands, Romania and Spain. Although replenishment orders have been placed or announced, deliveries will take time to restore even the previous inventories.

To address this issue and meet growing demand, steps have been taken to establish a European manufacturing capacity for *Patriot* interceptors. In late 2022, in direct response to the war in Ukraine, COMLOG, a joint venture between Raytheon and MBDA Deutschland, announced plans to establish a production line for the PAC-2 GEM-T interceptor with the goal of doubling output.[16] In 2024, under the ESSI structure and through the NATO Support and Procurement Agency, Germany, the Netherlands, Romania and Spain signed a framework agreement with COMLOG to enable the purchase of up to 1,000 PAC-2 GEM-T interceptors.[17] In the same year, construction of the facilities for the new assembly line began in Germany.[18]

Apart from the Turkish *Siper* Block-2, currently under development, the only other European-produced system broadly comparable to the *Patriot* in both range and mission profile is the Franco-Italian Eurosam SAMP/T. The system, which is in service with both France and Italy, employs the *Aster* 30 interceptor, which has a reported engagement range exceeding 150 km.

However, SAMP/T also faces significant constraints in terms of production capacity. The manufacturing process remains slow, shaped more by peacetime multinational industrial cooperation than by the demands of a high-intensity war. Before 2022, production timelines for a single missile were reportedly up to 42 months. Industry has begun to address this, with manufacturing time now at 24 months, alongside a goal of increasing production by 50% by 2026.[19]

With engagement ranges of approximately 150–160 km, the *Aster* 30 and *Patriot* PAC-2 currently represent the upper tier of Europe's SAM capabilities.

In contrast to Europe's long-range air defences, which remain heavily reliant on the US-made *Patriot* system, medium-range capabilities in Europe are more diverse. They include US and Israeli interceptors as well as several European-produced systems, many of which are successful adaptations of indigenous AAMs originally developed for European fighter aircraft.

Germany's Diehl first adapted the IRIS-T AAM for ground-based launchers in the IRIS-T SLS configuration, which offers a range of 12 km and was exported to Sweden. The system was subsequently developed into the IRIS-T SLM, featuring a larger interceptor with enhanced performance and a range of up to 40 km.

Germany ordered six IRIS-T SLM batteries in 2023, with initial operating capability declared in 2024, and is considering acquiring more. Bulgaria, Estonia, Latvia, Sweden and Switzerland have also placed orders. Continuing its incremental approach, Diehl announced the development of the IRIS-T SLX interceptor in 2024, with a range of 80 km.[20] The German Air Force has reportedly expressed interest in procuring this system too.[21]

The NASAMS system, developed jointly by Norway's Kongsberg and the United States' Raytheon, has also proven

A French SAMP/T long-range SAM system on display at the Paris Air Show, Le Bourget Airport, 19 June 2023. Credit: Ludovic Marin/POOL/AFP via Getty Images successful in Ukraine. It is in service with Finland, Hungary, Lithuania, the Netherlands, Norway and Spain. The system relies on US-made interceptors and radars, but the overall architecture is modular and allows for national integration. The initial design concept centred on adapting the AMRAAM for ground launch without modification. Later variants incorporated additional interceptors, including the AIM-9X *Sidewinder* II and the extended-range AMRAAM-ER.

In the United Kingdom, MBDA UK has developed the Common Anti-Air Modular Missile (CAMM), with a range of approximately 25 km. This is complemented by the CAMM-ER, which extends the range to more than 40 km.[22] CAMM is in service in the UK, and Poland is also acquiring the system to operate with its *Pilica* anti-air gun/missile systems. Warsaw has also selected the CAMM-ER as the interceptor for its *Narew* air-defence programme. In 2023, the UK and Poland signed a contract for the local production of more than CAMM-ER 1,000 missiles in Poland. MBDA and the Polish defence group PGZ also agreed to jointly develop longer-range version, designated CAMM-MR.[23]

Short-range requirements

The war in Ukraine has also changed perceptions of very short-range air defence (VSHORAD). For much of the post-Cold War period, these systems were viewed as a low priority. Western air forces were expected to secure air superiority early in any conflict, reducing the likelihood that front-line or rear-area troops would face threats from crewed fixed-wing or rotary-wing aircraft. On that basis, several European NATO members including Germany, the Netherlands and Denmark substantially reduced or fully dismantled their short-range air-defence capabilities, maintaining only limited stocks of man-portable air-defence systems (MANPADS).

Efforts are now under way to address this gap. Germany's Rheinmetall, for example, is currently developing a new generation of self-propelled VSHORAD systems centred on the *Skyranger* family of remote-controlled turrets. These can be fitted with different calibres of cannon and also very short-range SAMs. The *Skyranger* is being promoted as part of the ESSI, and various configurations are planned for procurement by Austria, Denmark, Germany, Hungary and the Netherlands.

A German IRIS-T SLM medium-range SAM system at the Todendorf military base in Panker, Germany, 4 September 2024. Credit: Gregor Fischer/Getty Images

Meanwhile, Poland has emerged as another major European producer of MANPADS. Building on Warsaw Pact-era design experience, it has developed the *Grom* and subsequently the *Piorun*, which has seen export success across Europe.[24] In France, MBDA manufactures the *Mistral* 3 in infantry, vehicle-based and naval configurations, with production scaled up in response to the war in Ukraine.[25] The UK produces the *Starstreak* system, also integrated onto various vehicle platforms, which has achieved limited export success. In addition to these systems, many European armed forces continue to field large numbers of US-made *Stinger* missiles. Sweden has long been one of Europe's leading MANPADS producers and has achieved broad export success with its RBS-70 system. The country now offers the improved RBS-70 NG (Next Generation) variant.[26]

OWA UAVs and lasers

The rapid proliferation of low-cost UAV technology, and its innovative and large-scale employment by Russia and Ukraine, has further sharpened focus on potential challenges, and also spurred efforts to develop new air defences to counter uninhabited systems. Rather than focusing on optimising existing systems or reducing their cost, there is growing interest in exploring new approaches which may offer a more viable and scalable response to the evolving threat environment.

There has recently been progress in applying laser technology for counter-UAV operations. In 2024, Israel confirmed the operational use of its *Iron Beam* laser system against Hizbullah UAVs, marking the first documented instances of laser-based air defence at scale.[27]

At first glance, directed-energy weapons such as lasers offer considerable advantages over conventional effectors in the counter-UAV role. The negligible cost per shot addresses both the economic asymmetry of using high-end interceptors against low-cost UAVs and the related issue of magazine depth. However, their power demands constrain mobility, effective range remains limited, and performance can deteriorate markedly under adverse weather conditions. Operational success also depends on precise tracking to minimise dwell time and achieve the desired effect. As a result, laser weapons are not expected to operate on their own but are more likely to be integrated into a broader mix of systems within layered air-defence architectures.[28]

France, Germany, Turkiye and the UK are pursuing point defence or short-range laser systems. For instance, the UK's *DragonFire* 50 kilowatt laser system, developed by the Defence Science and Technology Laboratory in cooperation with MBDA UK and other industrial partners, achieved its first successful interception of an aerial target during testing in 2024.[29] MBDA Deutschland and Rheinmetall have jointly developed a 20 kW Laser Weapon Demonstrator, which underwent successful trials on the German Navy's F124 *Sachsen*-class frigate between 2022 and 2023. France's Directorate General of Armaments (DGA) and CILAS have developed the 2 kW High-Energy Laser for Multiple Applications – Power (HELMA–P), which has undergone both land and sea trials.[30] While less powerful than the British and German laser systems currently under development, HELMA–P has already been deployed, most notably to provide short-range counter-UAV capability during the Paris 2024 Olympic Games.[31]

In addition to national programmes, European powers have also pursued collaborative development of laser technologies through the Tactical Advanced Laser Optical System (TALOS) initiative. Between 2019 and 2023, TALOS brought together a consortium of 16 countries to develop foundational technologies for a future laser weapon.[32] TALOS has since been succeeded by TALOS-TWO, a follow-on programme funded through the European Defence Fund, which aims to deliver an operational 100 kW laser system by 2030.[33]

The current multiplicity of programmes mitigates the risk of a single point of failure, in which the collapse of one effort would leave Europe without essential capabilities. However, it also disperses intellectual and financial resources that, if consolidated into fewer initiatives, might result in more significant and timely progress.

Two additional approaches to countering OWA UAVs and FPVs are also being explored: adapting low-cost UAVs to act as interceptors and developing lower-cost missiles. Given the relatively low financial and technical barriers to entry associated with interceptor drones, smaller start-ups rather than established defence primes are pursuing most projects in this field. Companies include Advanced Protection Systems of Poland, Alpine Eagle and Tytan of Germany, MARSS of the UK and Saudi Arabia, Nordic Air Defence of Sweden, Origin Robotics of Latvia, and TRL Drones of the Czech Republic.

Low-cost missile-interceptor efforts include MBDA Germany's *DefendAir* system, previously designated as the Small Anti-Drone Missile (SADM). To save time and development cost, the missile is derived from the company's existing *Enforcer* shoulder-fired infantry weapon. The Estonian start-up Frankenburg Technologies has also begun developing an affordable very short-range UAV interceptor, the *Frankenburg* Mk1.[34]

European missile defence

Ballistic-missile defence was once a source of controversy in Europe due to its perceived impact on strategic stability. However, it has gained renewed prominence in defence planning, driven by several factors. Over the past decade, advances in precision guidance and missile survivability have expanded the role of ballistic missiles beyond their traditional function as nuclear delivery systems. They are increasingly employed for conventional war fighting and coercion by adversarial states.

At the same time, progress in short- and intermediate-range ballistic-missile (IRBM) defence has demonstrated that such systems can be relatively effective. This has been evident in Ukraine's interception of Russian ballistic missiles and in the performance of Israel's layered missile-defence architecture during recent employment in the Middle East. These developments position missile defence not only as a war-fighting capability but also for deterrence.

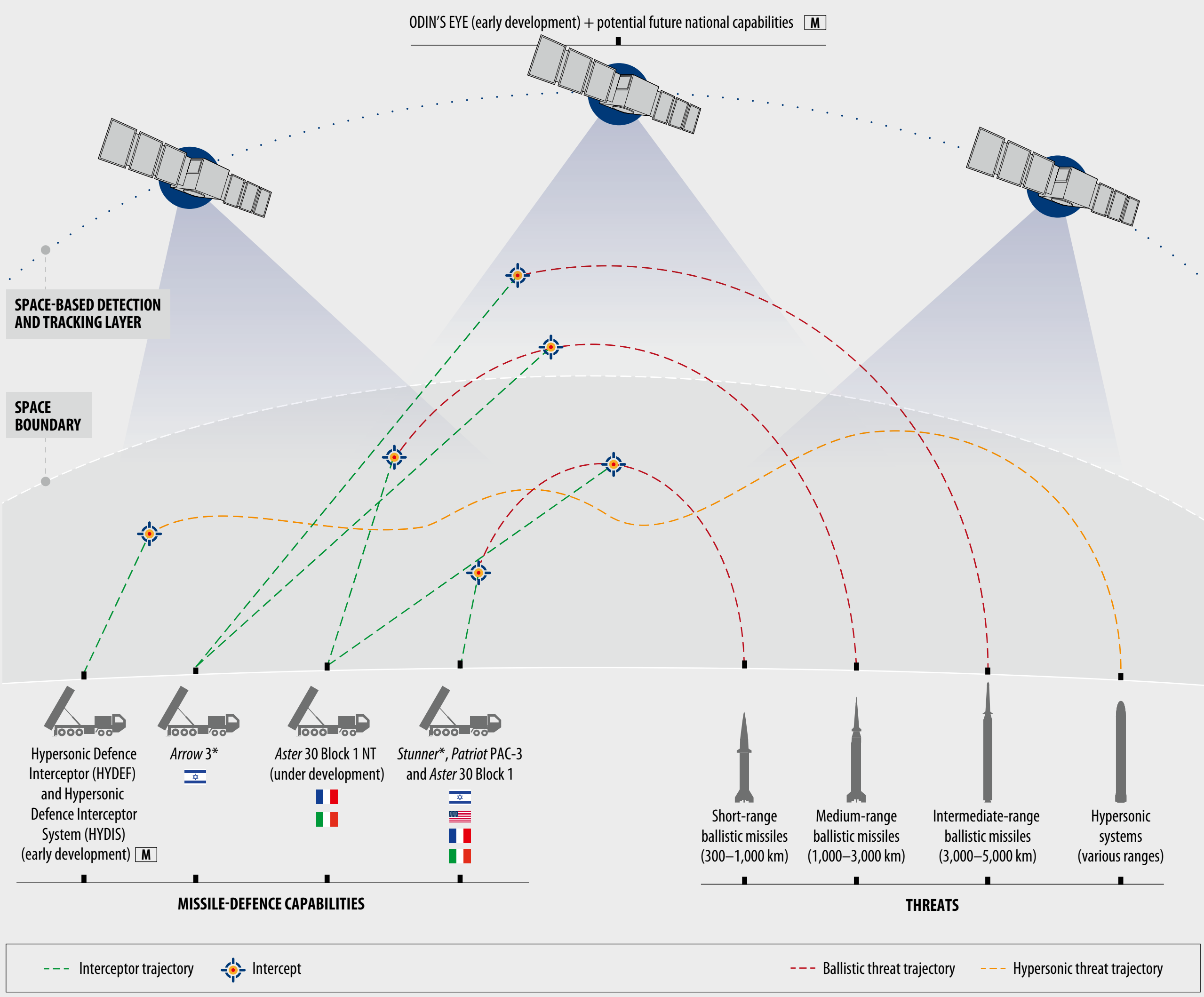
Establishing effective missile defence presents a distinct set of challenges compared to other forms of air defence. Chief among these is cost. Terminal-phase interceptors typically cost several million US dollars each, while mid-course interceptors for IRBM defence can cost tens of millions per unit.[35] Given that multiple interceptors can be launched against a single target to ensure a high probability of kill, the cumulative cost exceeds that of the attacking missile system. This asymmetry can impose a disproportionate financial burden on the defender, though the cost of not intercepting a missile – and the ensuing damage – also needs to be considered.

The technical complexity of ballistic-missile defence has resulted in a limited number of dedicated systems available on the global market. Such capabilities are difficult to develop and remain largely concentrated in the US and Israel. This concentration not only limits supplier diversity but also creates production bottlenecks.

These dynamics are reflected in the current state of European ballistic-missile defence, which remains characterised by capability gaps, industrial constraints and uneven national investment (see Figure 3.2).

The most widely deployed form of ballistic-missile defence is terminal-phase interception, which targets missiles during their final descent, typically after re-entry into the atmosphere. Terminal systems can also engage quasi-ballistic or aero-ballistic threats, such as Russia's *Iskander*, which follows a depressed trajectory and remains within the atmosphere throughout its flight. These systems are generally more

Figure 3.2: **Current and future European ballistic-missile-defence capabilities**



Note: Flags indicate the origin of the system. M = Multinational. *Ongoing procurement.

Source: IISS analysis

cost-effective than mid-course interceptors and have demonstrated operational effectiveness in recent conflicts. However, their relatively short engagement windows and constrained coverage areas often necessitate the launch of multiple interceptors per incoming missile to ensure a high probability of kill.

Current European terminal-phase missile-defence capabilities rely on the US, either in the form of US-made missile-defence systems operated by national militaries or US systems deployed to Europe.

As of mid-2025, several European nations operate *Patriot* air- and missile-defence systems equipped with PAC-3-family interceptors, which are optimised for countering tactical-ballistic-missile threats. These countries include Germany, Greece, the Netherlands, Poland, Romania, Sweden and Ukraine. Spain and Switzerland have signed procurement agreements and are in the process of integrating PAC-3 interceptors into their respective air-defence architectures. These capabilities are reinforced by US *Patriot* systems deployed to the US base at Baumholder in Germany.

Beyond the sovereignty debate, industrial bottlenecks constrain Europe's reliance on the *Patriot* system for terminal missile defence. Demand for PAC-3 MSE interceptors has risen sharply due to sustained Ukrainian use and parallel procurement by multiple NATO members. Although Lockheed Martin has expanded annual production from around 350 missiles in 2018 to over 500, shortages in key subcomponents such as rocket motors have hampered higher production rates.[36] The previous prioritisation of deliveries to Ukraine has led to delays in fulfilling orders for other customers, including Poland and Switzerland.[37]

To help expand overall manufacturing capacity for *Patriot* interceptors and ensure that a portion of programme-related expenditure remains within their respective national economies, several European countries have sought to join the system's supply and production chain. Poland and Spain have begun efforts to produce selected components of the *Patriot* PAC-3 system domestically.[38] Germany's Rheinmetall has announced plans for a joint venture with Lockheed Martin aimed at the potential production of up to 250–300 PAC-3 interceptors per year.[39]

The *Aster* 30 interceptor, developed by the Franco-Italian Eurosam consortium, is currently the only European missile with terminal ballistic-missile-defence capability; the producer has stated it is capable of intercepting SRBMs with ranges up to 600 km.[40] It is fielded in the land-based SAMP/T system, operated by Italy, France and Ukraine, and in its naval variants by France, Italy and the UK, where it is designated *Sea Viper*. Naval versions of the missile have successfully intercepted Ansarullah (Houthi)-launched anti-ship ballistic missiles during deployments to the Red Sea.[41] While SAMP/T has proved valuable in Ukraine, comments by President Volodymyr Zelenskyy suggest that the system may not match fully the performance of the *Patriot* against ballistic missiles.[42]

To alleviate some of these shortcomings, manufacturers are pursuing efforts to modernise the SAMP/T system and expand its anti-ballistic-missile capabilities. Work on the modernised SAMP/T NG system is advancing, with entry into service expected in 2026. The upgraded system will incorporate the more capable radars and the *Aster* 30 Block 1NT missile, the latter currently still in development. The Block 1NT is expected to provide improved engagement capability against SRBMs and engagement capability against medium-range ballistic missiles (MRBMs) with ranges of up to 1,500 km.[43]

In addition to domestic initiatives and cooperation with the US, several European countries have begun exploring Israeli and Israeli–US systems to provide missile-defence capabilities. In 2023, Finland signed a contract for the acquisition of a single launcher unit for the *David's Sling* system, which is capable of intercepting aircraft, UAVs, cruise missiles, and tactical ballistic missiles with ranges of up to 300 km.[44] The German Air Force has announced plans to procure the *Arrow* 4 system, currently under development as the successor to *Arrow* 2. *Arrow* 4 is intended to provide coverage in the tier between the *Patriot* system and the exo-atmospheric *Arrow* 3 and is reportedly designed to have a capability to engage manoeuvring hypersonic targets.[45] Greece, meanwhile, has announced plans to develop a layered IAMD architecture incorporating Israeli systems, although few details have been made public.[46]

US Navy personnel salute in front of the *Aegis Ashore* missile-defence facility in Deveselu, Romania, 12 May 2016. Credit: Daniel Mihailescu/AFP via Getty Images

Exo-atmospheric mid-course interception is both more attractive and more demanding. By avoiding the limitations of the brief terminal phase, exo-atmospheric interceptors can engage targets at significantly greater ranges, thereby extending the territorial footprint that is defended. The longer engagement timeline also enables a shoot–look–shoot approach, allowing a second interceptor to be launched only if the first fails to successfully engage the target. Exo-atmospheric interceptors, however, are significantly more expensive than endo-atmospheric systems.

As of mid-2025, exo-atmospheric mid-course interception capabilities in Europe are provided only by the US. While the US THAAD system is capable of endo- as well as limited exo-atmospheric intercepts, no batteries are permanently stationed in Europe. For full exo-atmospheric mid-course defence the US has adapted its *Aegis* combat system, which includes the AN/SPY-1 radar and the Mk 41 vertical launching system, for land-based deployment. Installations of this configuration, known as *Aegis Ashore*, are located at Deveselu in Romania and Redzikowo in Poland. These sites can be used to launch multiple variants of the SM-3 interceptor, which is designed to engage MRBMs and IRBMs. The SM-3 Block IIA variant has also demonstrated an ability to intercept intercontinental ballistic missiles under controlled test conditions.[47] These land-based assets are supported by a force of US Navy *Aegis*-equipped destroyers permanently forward-deployed to Rota, Spain.[48]

Germany is currently leading the most advanced initiative to establish a sovereign European mid-course missile-defence capability. In late 2023, it signed a contract with Israel for the purchase of three *Arrow*

3 batteries at a cost of EUR 3.6 billion (USD3.89bn), marking the largest defence sale in Israel's history.[49] In contrast to other German procurement programmes, which have often faced bureaucratic delays, the *Arrow* 3 acquisition has progressed at an accelerated pace. Construction of the first site began in early 2025, with initial radar systems expected to become operational by the end of the year. Full operational capability is planned by 2030.[50]

With an interception range of up to 2,400 km, the *Arrow* 3 system provides a defended footprint that extends well beyond German territory and offers coverage to other parts of Europe.[51]

While this geographical reach is significant, the acquisition has also attracted criticism. Some argue that the primary missile threats from Russia, aside from cruise missiles, consist of aero-ballistic systems such as the *Iskander* and *Kinzhal*, which remain within the atmosphere throughout their flight and are therefore not within the *Arrow* 3's engagement envelope. The use of the *Oreshnik* system has introduced a threat with an exo-atmospheric mid-course phase, theoretically justifying the relevance of systems like *Arrow* 3. Critics, however, maintain that the cost–benefit balance remains questionable, given the limited number of *Oreshnik*-class missiles that likely exist, and the high procurement and sustainment costs associated with *Arrow* 3. Proponents counter that the system should be viewed as a future-oriented investment and also highlight the utility of its associated EL/M-2080 *Green Pine* radar for enhancing space situational awareness.[52]

MBDA's *Aquila* hypersonic interceptor concept on display at the Farnborough International Airshow, UK, 22 July 2024. Credit: John Keeble/Getty Images

High-speed demands

Mach 5+ offensive systems such as the *Kinzhal*, combined with Russia's continuing interest in developing hypersonic cruise missiles and hypersonic glide vehicles, provide an additional challenge for air defence. The ability to manoeuvre during mid-course flight, combined with flight in the upper atmosphere which is poorly covered by detection sensors, pose problems for defenders. Existing sensor networks, designed primarily to track traditional ballistic missiles, are not optimised for detecting and following agile targets travelling at hypersonic speeds within the atmosphere.

Current defence capabilities against hypersonic threats remain limited. The US-developed SM-6 missile is reportedly capable of engaging hypersonic targets in the terminal phase and was tested in March 2025 against a manoeuvring hypersonic target vehicle. The test, however, involved a simulated intercept in which the target was real but the missile engagement was virtual, limiting insights into actual interceptor performance under operational conditions.[53] In Ukraine, *Patriot* systems have successfully intercepted air-launched *Kinzhal* missiles, which Russia describes as hypersonic weapons but which may not consistently meet the technical thresholds for sustained hypersonic performance.[54] Thus, while certain US-produced systems have demonstrated some capability against manoeuvring high-speed targets, neither the US nor European states currently possess an interceptor designed specifically for hypersonic defence.

In Europe two parallel studies are exploring the development of a hypersonic interceptor. The European Hypersonic Defence Interceptor (HYDEF) was launched in 2023 and is managed by the Organisation for Joint Armament Cooperation (OCCAR), with a total budget of approximately EUR110m (USD118.97m). The HYDEF consortium brings together 13 European companies, with overall programme management led by Spain's SMS and technical coordination provided by Germany's Diehl Defence.[55] In 2023, Diehl unveiled an initial concept for the interceptor, known as IRIS-T HYDEF, which is intended to engage targets at altitudes of up to 50 km and at ranges of up to 100 km. Company materials showed two possible configurations: one powered by rocket motor and the other by a ramjet.[56]

In late 2023, the European Commission assigned OCCAR the management of a second programme focused on the development of hypersonic interceptor technologies, designated the Hypersonic Defence Interceptor Study 2 (HYDIS2). The initiative has a total budget of approximately EUR115m (USD124.38m) and brings together 19 industrial partners, with MBDA France serving as the consortium leader.[57] MBDA France had already been engaged in hypersonic-missile-defence research for more than five years under the *Aquila* project, which builds on core technologies derived from the *Aster* 30 missile and its subsequent evolution. In 2023, the company presented a mock-up of the interceptor at the Paris Air Show.[58]

The duplication of European hypersonic defence programmes has prompted criticism. Some have argued that the launch of the HYDIS initiative reflected political considerations rather than operational requirements or planning efficiency, with France seeking to ensure that its national industry would lead a European hypersonic-defence effort.[59] In response, others have criticised the HYDEF programme for excluding MBDA France as the European defence firm with the most experience in the development of high-performance interceptors.[60] Europe is pursuing two distinct and competing programmes in the same capability area.

Threat systems operating in the hypersonic-flight regime present detection and tracking challenges. This is in part because the altitude window in which they are flown is not well served by the current surveillance architecture. Space-based sensors could provide one means of addressing the detection problem, and more broadly, space-based early-warning satellite constellations are increasingly important for IAMD.

European nations currently lack a space-based missile warning and tracking architecture. Space-based early-warning data has been made available to European forces during foreign military operations, including deployments to the Red Sea in response to Houthi attacks. However, existing systems are primarily optimised for detecting intercontinental-ballistic-missile launches and have proven less effective against SRBMs, which generate weaker infrared signatures.[61]

To address the gap in space-based sensor capabilities, the European Union co-funded the ODIN'S EYE study in 2021 to examine the technological foundations, operational requirements and architectural trade-offs for a system capable of early warning and tracking of ballistic- and hypersonic-missile threats.[62] This effort was followed in 2023 by ODIN'S EYE II, a more expansive three-year programme involving 43 industrial and institutional partners, coordinated by Germany's OHB System AG.[63]

Although Europe lacks operational space-based missile warning, it can draw on some prior experience. In 2009, France launched two experimental infrared satellites under the SPIRALE programme to explore early warning from space.[64] In parallel, the German Fraunhofer Institute, in cooperation with defence-industry partners, has developed a design concept for a European space-based early-warning system.[65]

ODIN'S EYE has, however, drawn criticism for its fragmented structure and slow progress. Observers have pointed to the involvement of a large number of participating entities as a source of inefficiency and cumbersome decision-making. According to media reports, Germany is now exploring the development of an independent national capability. As part of this effort, the German Ministry of Defence is reportedly considering the procurement of two infrared early-warning satellites from Airbus to provide an interim or parallel national capability.[66]

Active and passive

IAMD also includes civil defence and, at the other end of the spectrum, offensive action 'left of launch': i.e., action before the threat, be it a ballistic or cruise missile or hypersonic glide vehicle, is in flight.

Passive civil protection, in the form of adequate early warning and the ability to shelter, has been effective where conventionally armed missile strikes are aimed at population centres. This is less the case when the target is either military or critical national infrastructure (CNI), though personnel protection remains important.

Including a left-of-launch approach within IAMD offers the potential advantages of a more favourable cost-exchange between the offence and defence, the possibility of preventing the saturation of missile defences, and the opportunity to eliminate launch platforms, which are typically more limited in number than the munitions they support. Israel appears to have successfully implemented this approach, claiming to have destroyed up to two-thirds of Iran's MRBM launchers during its campaign in June 2025.[67]

At the same time, kinetic left-of-launch strategies present considerable operational challenges. They require extensive intelligence, surveillance and reconnaissance capabilities, particularly for the detection, tracking and post-attack assessment of targets such as road-mobile missile launchers. This remains a shortfall in Europe. In a contested environment, where ground-based air defences are dense and air superiority cannot be assumed, such operations also depend on strike assets that are both survivable and capable of operating at extended ranges. When the target is time-sensitive, left-of-launch approaches further require highly responsive weapon systems with short reaction times and reduced time of flight. Europe currently lacks such systems but is actively exploring the development of deep precision strike capabilities, including conventionally armed ballistic and Mach 5+ weapons.[68]

Conclusions

Europe today has boutique IAMD capabilities, with some of the advanced technologies, sensors and missiles required, and the relevant defence-industrial base, to pursue these further. What it does not have is the volume, either in inventory or production capacity, nor does it have the comprehensive sensor suite to support all of IAMD's information demands, from the battlefield to CNI. Efforts to address many of these issues are fragmentary rather than concerted. Symptomatic of this are the hypersonic-glide-vehicle and cruise-missile-defence studies under way, with competing political, industrial and military imperatives readily apparent. Europe will need a focused and sustained approach to IAMD in order to better address the threat posed by Russian capabilities.

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