Air and missile defence in Europe

IHS Jane's Strategic Assessment and Futures Studies Centre

Rising tensions

As regional security deteriorates, Europe is bolstering its national anti-ballistic missile defences

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(Top) A THAAD missile interceptor is put through an operational test in Hawaii (Below) US Army Private Jonathan Valentine demonstrates how to reposition a Patriot missile launcher while on an exercise with the Romanian Air Force.

Photography: Tech Sgt Brian Kimball/ US Missile Defence Agency/Flickr

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Editorial

IHS Jane's Strategic Asessments and Futures Studies Centre is pleased to present this special report examining the future of air and missile defense in Europe

Air and, particularly, missile defence efforts in Asia-Pacific and the Middle East have outpaced activity in Europe for much of the past decade. However, Russia's State Armaments Programme, annexation of Crimea and invasion of Eastern Ukraine, escalatory rhetoric and structural state weakness have recently infused the missile defence discussion in Europe with a heightened sense of urgency.

So, too, have broader concerns about proliferation of unmanned systems, missiles and rockets to and from Iran, as well as the possibility of a rogue launch or coercive use of air and missile systems. NATO and several individual European states – notably, Poland, Germany and the Netherlands – are investing in multiple, sometimes competing, approaches to meeting the diverse, dynamic and durable air and missile defence challenge. Industry leaders will be presented with a target rich and competitive market. They will need to work closely with end-user communities to strike complicated, but critical, balances between several tensions and emerging requirements.

Layered capabilities

Notably, industry and militaries must develop layered capabilities to meet a vigorous and varied threat and be able to create high-degrees of interoperability with allies and regional neighbours, all while managing the typically high-costs associated with air and missile defence.

They also must balance the need to develop and deploy proven and reliable capabilities that meet immediate challenges while still providing the possibility of upgrading capability or incorporating new technologies (such as gallium nitride radar technologies, 360-degree radars, and open architectures to enhance plug-in-and-fight interoperability) to meet the certainty of new threats. The need in some cases to engage local industry introduces potentially complicating dynamics into an already hyper-competitive environment and could extend timelines associated with the development, delivery and deployment of air and missile defence capabilities.

Ultimately, the ability of industry competitors to provide a proven capability that will have multiple channels – user communities, lower cost technologies, new operational concepts and capacity to leverage the full-range of company resources – for reducing cost will provide significant competitive advantages in an active market.

This supplement is divided into four linked sections that seek to:

- frame the discussion around the importance of air and missile defence capability in a shifting global context;
- explore the current state and possible future trajectory of European missile defence and the air and missile threats it faces;
- assess active or impending air and missile defence programmes in Europe and identify key market trends, procurement priorities or emerging operational requirements; and
- explore a series of concepts, tensions and requirements for national and multi-national missile defence systems.

Research and analysis contained in the supplement leverages ongoing SAFS Centre research initiatives (*NATO Futures, Emerging Military Competitions* and *Defence Industry 20YY*) as well as *IHS Jane's* reporting, secondary source research and interviews with and commissioned materials from a dozen different subject matter experts within *IHS AD&S* and our network of experts and industry contacts. ■

This report has been commissioned by Raytheon, but IHS AD&S retained full control over the content

Photography: Tech Sgt Brian Kimball/DoD/Flickr

A Romanian soldier inspects a MIM-23 missile system during an exercise with the US in Capul Midia on 7 November 2016.

The global context

A worldwide perspective on the drivers behind missile-versus-missile defense competition

The missile-versus-missile contest is one of six domain area competitions the SAFS Centre monitors due to their central role in shaping the future of military conflict, as well as the trajectory of global and regional geopolitical competitions.

The confluence of these pervading geopolitical, technological, military and security trends and drivers ensures that capabilities and related conepts steadily evolve, or even radically shift at times. Such developments could undermine, abrogate or, conceivably, reinforce strategic balances or stabilise military imbalances. Disturbances to these could, in turn, drive regional competitions and security environments along new, potentially destabilising and perhaps under-explored, pathways in a shifting global context.

The global context

In a November 2015 speech in Aspen, Colorado, Robert Work, the US Deputy Secretary of Defense, said: "Great power competition has returned." His comment was accurate, but also incomplete: intensified competition is occurring between far more than the small handful of great powers. Think of Iran and Saudi Arabia (and other Gulf States); or China and Japan (or India); or the tense situation on the Korean peninsula.

Rising competitive geopolitical forces are the result of a sense that the predominante US/Western-led geopolitical frameworks of the past 25 years are eroding or faltering in response to the manifold pressures of the modern world. Some of these are domestic in origin or borne of widening gaps in values, perceptions and priorities between key stakeholders in these frameworks.

Other pressures, though, are driven by state and non-state actors seeking to establish a new type of international relations, in which rules and institutions are changed and global power and influence is diffused from the US and its closest allies. China's leadership consistently raises this theme, frequently coupling it with the concept of "win-win co-operation" with few conditions between China and its partners. Russia, too, has embraced and furthered the narrative of a transforming geopolitical system and the frailty of existing norms, such as those around arms control. Russia's 2013 Foreign Policy Concept said: "The principal and emblematic feature of the current international landscape is the deep-seated transformation of the geopolitical landscape, the essence of which is transition to a polycentric or multipolar world ... [in this environment] states seek to augment their offensive potentials and develop new kinds of weapons thus eroding the structure of global security and even the system of arms control agreements."

The erosion of existing geopolitical frameworks has increased the incentives for both state and non-state actors to take greater risks. Sound frameworks tend to engender (mostly stabilising) norms that bind behaviours and ensure there are consequences for violating these norms. Over the past two years, the international system has experienced more assertive behaviours – more rules breaking – from many states with few, if any, consequences – from Crimea to

Photography: Master Sgt Sean M Worrell/US Air Force/Flickr

US soldiers talk after a routine inspection of a Patriot missile battery at a Turkish military base in Gaziantep in 2013.

COMMON THEMES

Missile defence activity in Asia and the Middle East are not necessarily a perfect analogue for understanding the future challenges, opportunities and requirements for missile defence in Europe. However, several common themes can be applied to discussions of European missile defence.

- The persistent need for layered missile defence to meet a multi-dimensional threat.
- The growing need for interoperability between layers in a national system and between multi-national partners.
- The need to evolve deployed capabilities over time.
- The cost-imposing element of developing missile defence capabilities and concepts in response to robust A2/AD capabilities.

the Korean peninsula to the South China Sea. The result, for now at least, is a convulsive world vulnerable to repeated retching shifts and brazen applications of national power. Defence and security communities will need to expand their thinking about likely, possible and even previously un- or under-explored plausible threats; namely, missile strikes against Europe or, perhaps more likely, Russian use of missile threats to subordinate, destabilise and intimidate NATO allies or other vulnerable states in the former Soviet "near abroad".

The diffusion and clever use of advanced military and, in some cases, dual-use and commercial technologies is also affecting the global context, amplifying geopolitical competitions and shaping the current and future parameters of air and missile defence challenges. Proliferation of advanced technologies affords actors the opportunity to develop asymmetric capabilities and operational concepts that can: hold more militarily advanced adversary or competitor assets at risk; create anti-access/area denial (A2/AD) cordons in which adversaries cannot effectively operate; and/or deter, dissuade or coerce adversaries and competitors in times of crisis. Cyber-technologies, effective strategic communications and influence operations, electronic warfare weapons (such as jammers), swarmed unmanned systems, enhanced sensors, nuclear weapons and, of course, cruise and ballistic missiles top the list of these diffused and impactful technologies that target the vulnerabilities of modern militaries and liberal political systems.

Another challenge posed by the diffusion of novel technologies and capabilities is the creation of unbalanced cost curves. Developing asymmetric capabilities is frequently inexpensive, but defending against them can impose disproportionate costs, a lesson those tracking missile defence issues will know

well. Flipping asymmetric cost curves by developing new competition-affecting technologies is among the primary motivations for the US Department of Defense's recently announced Third Offset Strategy.

Missile-versus-missile defense

The missile-versus-missile defense competition has unfolded and escalated for well over a decade as part of the geopolitical struggle in Asia-Pacific and the Middle East. In the Western Pacific, North Korea's development and repeated testing of ballistic missiles – over 20 ballistic missile tests in 2016 as well as two nuclear tests – and the opaque and unpredictable decision-making of Kim Jung Un have created heightened anxiety in South Korea and Japan about missile attacks or coercive use of North Korea's missile and nuclear programmes. Both countries have invested in enhanced and layered missile defence capabilities as a result.

In July 2016, the South Korean government agreed to deploy Lockheed Martin's Terminal High Altitude Area Defense (THAAD) system. Details of the deployment are still being determined, but the system is expected in 2017 to join Raytheon's Patriot PAC-3 and PAC-2 systems that are being upgraded to the new configuration.

Japan is adding new layers to its existing air and missile defence capabilities as well, possibly THAAD or the Aegis Ashore batteries that have formed the foundation of NATO's European Phased Adaptive Approach (EPAA) missile defense system (see pages 6-9). Japan's defence ministry is also bringing forward the purchase of additional ground-based Patriot PAC-3 interceptor missiles, among other moves designed to enhance layered missile defence.

These announcements have not been well-received in China, which has expressed disquiet with South Korea's deployment of a THAAD system that will include coverage of Chinese territory, limiting potential air and missile operations within China's sovereign territory (NATO has a similar concern with the deployment of Russian S-400 air defence systems that could conceivably target NATO assets operating in NATO territory: Poland, for example).

> "The proliferation of missile and rocket technology to non-state actors in the region has produced another layer of air and missile defence concerns in the Middle East"

Moreover, these systems and other missile defence systems operating in Northeast Asia could compromise the efficacy of China's A2/AD modernisation effort. A key component of this programme is the development and deployment of increasingly capable ballistic missiles and land, air and ship-launched cruise missiles that together can overwhelm existing missile defences. The US Department of Defense highlighted this threat from China's military modernisation in multiple annual reviews to Congress, as well as the 2014 *Quadrennial Defense Review*, which noted: "Growing numbers of accurate conventional ballistic and cruise missile threats represent an additional cost-imposing challenge to US and partner naval forces and land installations."

The air and missile defence challenge is also playing out across the Middle East. Iran, in particular, is developing and diffusing unmanned systems, missile and rocket technology designed to "compensate for the weakness of its air force and as a credible deterrent", according to *Jane's Defence Weekly* in its October 2015 article "Gulf Shield: Missile threats and defence in the GCC".

Many Gulf States have responded by upgrading their current missile defence systems or procuring multiple overlapping and layered air defence systems capable of countering current and future Iranian airborne threats. The UAE has upgraded its Patriot anti-ballistic missile defence capabilities to PAC-3 standard while also becoming the first export customer to equip the THAAD system. Kuwait and Saudi Arabia have committed to upgrading their ageing Patriot batteries to PAC-3, while Qatar is due to have 10 Patriot PAC-3 batteries operational by the end of the decade. While acknowledgement that regional air and missile defence collaboration is useful, US-led efforts to forge a collective approach to missile defence amongst Gulf States has thus far been stymied by individual security concerns and regional political issues.

The proliferation of missile and rocket technology to non-state actors in the region has produced another layer of air and missile defence concerns in the Middle East (with potential consequences for Europe as well). Saudi Arabia has claimed on multiple occasions in the past year to have intercepted missiles and rockets fired by non-state armed groups within Yemen, including on 21 June 2016 when a Saudi Patriot battery operating within Yemen shot down a projectile from a BM-27 Uragan multiple rocket system based in Yemen. Israel is also threatened by saturation attacks from non-state groups armed with a huge cache of proliferated short-range rockets and has developed a robust layered system as a result that includes Iron Dome, David's Sling, Arrow-3 and Patriot. ■

Current and future threats

Since Russia annexed Crimea and invaded eastern Ukraine in early 2014, NATO and some European states have renewed their focus on the diverse, dynamic and durable threat to Europe and the evolving missile defence landscape that it has precipitated

Missile defense in Europe has lagged behind efforts in Asia and the Middle East as the continent sought to balance a spectrum of more urgent threats and crises: terrorism, the war in Afghanistan and Libya, the fallout of the global financial crisis, the rise of nativists and populist movements, and, most recently, immigration from the Mediterranean, the Syria conflict, the coup and purge in Turkey, Brexit and existential threats to the European project.

However, the threat environment over the past five years – and especially since the Russian annexation of Crimea and invasion of eastern Ukraine in early 2014 – has changed. In response, NATO and individual European states are demonstrating renewed focus on the diverse, dynamic and durable air and missile threat to Europe.

The EPAA

For NATO, the Europe-wide missile defence discussion started in the mid-2000s and came to fruition in September 2009 when US President Barack Obama launched the European Phased Adaptive Approach (EPAA). It became a NATO programme in 2010. NATO says the EPAA is "purely defensive" and of "limited capability" to provide enhanced security to allies in an uncertain and accelerating threat environment.

NATO's website explains: "Proliferation of ballistic missiles poses an increasing threat to Allied populations, territory and deployed forces. Many countries have, or are trying to develop or acquire ballistic missiles. The proliferation of these capabilities does not necessarily mean there is an immediate intent to attack NATO, but it does mean that the Alliance has a responsibility to take this into account as part of its core task of collective defense."

The programme originally involved four progressive phases of capability development and deployment of both sea- and land-based ballistic missile defence systems (see chart on page 9). In May of 2015, work was completed on the installation of the Aegis Ashore capability in Romania – combining Lockheed Martin's Aegis ballistic missile defence system with Raytheon's SM-3 interceptor. The second phase of the programme became fully operational in July 2016. Phase III plans to install an Aegis Ashore platform in Poland in 2018.

Phase IV was cancelled in March 2013 purportedly due to cost and capability concerns. Some viewed the cancellation of Phase IV as a means of engaging Russia, which strenuously objected to all of EPAA, but especially the Phase IV deployment of longer-range interceptors as a threat to Russia's strategic nuclear deterrent.

> "The resolution of the nuclear issue does not obviate the need for ballistic missile defences to counter the Iranian ballistic missile threat"

The threat from Iran

EPAA was originally conceived to defend against and deter either coercive use of advancing missile capabilities by or a missile strike from an isolated, alienated and antagonistic Iran. Some observers, especially those in Iran and Russia, argue that the justification for the programme was eliminated by the Joint Comprehensive Plan of Action (JCPOA) agreement, signed on 14 July 2015, which placed limits on Iran's nuclear and ballistic missile programme in return for the phased lifting of international sanctions. These arguments frequently site President Barack Obama, who said in 2009: "If the Iranian threat is eliminated, we will have a stronger basis for security, and the driving force for missile defence construction in Europe will be removed."

Such benign assessments are premature and optimistic, a point a US Department of State official effectively made to *IHS Jane's* on 16 July 2015, two days after the JCPOA agreement was signed. He said: "Iran has the largest inventory of ballistic missiles in the Middle East, which continues to be a source of concern to us and the international community." Trust between the US/Europe and Iran remains low, and fundamental disagreements remain over the future of Iran's nuclear and missile capabilities.

These capabilities have progressed in recent years. Reed Foster, an *IHS AD&S* contributor responsible for the *IHS Jane's* Middle East and North Africa capability assessments, noted: "The advancement and growth of an offensive missile capability has allowed Iran to maintain a credible threat to its potential adversaries, primarily regionally, but increasingly beyond, as Iranian missile technology continues to extend the envelope of weapons range, accuracy and reliability."

Foster added: "Iranian rocket and missile capabilities are oriented toward ... overwhelming regional rivals' missile defence capabilities with short-to-medium range ballistic missiles, anti-ship missiles as well as various long-range rockets launched from multiple sea-and shore-based platforms."

Recent development efforts have extended the range of several ballistic missile programmes well beyond the vicinity of the immediate Persian Gulf. The recently-tested Emad, has an estimated range of 1,700km with a payload capacity of 750kg; late-series Qadr F- and H-series variants possess a range in excess of 1,700-2,000km with a 750kg payload; and solid-propellant Sejil-2

two-stage ballistic missiles have a range of up to 2,200km with a 750kg payload. These all have the capacity to threaten or strike Europe in response to real or perceived threats against the Islamic Republic, as well as to hold European assets and infrastructure at risk in times of crisis. Foster also believes advancements reportedly made in re-entry vehicle technology would also indicate that Iran seeks a weapon that could potentially penetrate the defences of a state with moderate to advanced air-defence technologies.

The Iranian missile challenge to Europe is complicated by what Foster calls "unconventional and asymmetrical warfare doctrine". Rapid saturation attacks with short-to-medium range guided missiles or rockets upon naval or commercial shipping vessels, port facilities, urban population centres or offshore energy infrastructure remains a cornerstone of IRGC Navy doctrine and are reflective of IRGC approaches more broadly to implementing the full suite of its asymmetric capabilities. Should such tactics be exported to the Mediterranean during any potential conflict, even modest tactical success would likely result in significant psychological and economic impacts in Europe.

Beyond its development of weapon systems, Iran is also suspected of actively supporting the export of missile technology and employment to further empower proxy forces aligned to its geopolitical aspirations, such as Lebanese Hizbullah. Missile technologies ranging from the pervasive 122mm Katyusha rocket artillery possessing a range of 20km to the more advanced Iranian-manufactured 75km Fajr-5 systems have been used by Hizbullah against Israel in various conflicts over the past decade.

Although Europe is unlikely to be confronted with the thousands of stockpiled missiles that induced the rapid development and fielding of Israel's Iron Dome and David's Sling systems, European states remain vulnerable to these types of asymmetric attacks, especially during times of crisis.

The threat from Russia

The missile threat to Europe goes well-beyond Iran's missiles and proliferation technologies to state and non-state actors. The threat from Russia is real and current and is a

Phase II of the European phased adaptive approach (EPAA) to missile defence saw SM-3 Block IB interceptors (here launching from a ship) deployed in Aegis Ashore batteries in Romania in 2016.

Photography: US Missile Defence Agency/Flickr

powerful driver of the ongoing discussion of missile defence in Europe.

NATO has resisted publically highlighting the missile threat from Russia as a justification of the continued development and deployment of EPAA. Such a statement would have destabilising effects on the (admittedly already taut) US/NATO relationship with Russia. In addition, it would play directly into the post-Yeltsin Russian narrative of a rapacious US and West preoccupied with targeting, provoking and diminishing Russia as part of an inexorable move east to tame, subsume or defeat the Russian state. Olga Oliker, director of the Russia and Eurasia programme at the Center for Strategic and International Studies in Washington, captured this mind-set in an interview with the *Christian Science Monitor* in August 2016. He said: "The Russians are terrified of us. They see themselves as pushing back against US hegemony – and they really do see this, this isn't just rhetoric."

Nonetheless, the prominent and coercive displays of Russia's military strength, its risk-prone foreign policy, bellicose rhetoric and even structural state weakness are driving national and multi-national development and modernisation of varying tiers of missile defence systems in Europe.

Negative response

Russia's response to the EPAA and to layered missile defence programs popping up across Europe has been strongly negative. The interplay between European missile defence and Russian rhetoric has had an escalatory effect on the US/NATO-Russia competition in Europe and beyond.

Russia objects to the EPAA (and European missile defence more broadly) as a direct and proximate threat to Russian security. Russia also views the EPAA as an effort to fundamentally upset the strategic balance in Europe by, first, seeking to abrogate Russia's strategic nuclear deterrent and, second, by starting a spiralling arms race to escalate tensions between the West and Russia and help delay geopolitical transitions away from Western-led institutions.

These connected sentiments were captured in a July 2016 essay by Sergei Karaganov, an influential Russian scholar and advisor on security issues to President Putin. Dr Karaganov wrote: "By placing missile defence systems in Europe, the West is sort of inviting Russia to withdraw from the (INF) treaty and deploy missiles that can destroy these systems almost instantly. This would complete the picture with a new edition of the missile crisis of the late 1970s and early 1980s and a new round of structured military and political confrontation in Europe."

There is no current evidence that the EPAA (or any other system currently under consideration by individual European states) would threaten Russia's strategic inter-continental ballistic missile deterrent. The cancellation of Phase IV of the EPAA was designed – implicitly if not explicitly – to reassure Russia that this was not an objective of the programme. Moreover, a 2015 RAND Corporation report asserted that research and simulations showed: "The restructured EPAA system does not pose a threat to Russian ICBMs. The interceptors at Deveselu (Romania) are not capable of reaching Russian ICBMs. In addition ... when real-world, operational time delays are imposed the (SM-3 Block II) interceptors at Redzikowo (Poland) have no capability against Russian ICBMs."

> "At the moment the interceptor missiles installed have a range of 500km, soon this will go up to 1,000km, and worse than that, they can be rearmed with 2,400km-range offensive missiles even today, and it can be done by simply switching the software"

Unsurprisingly, the Russian government has not been assuaged by these assurances and continues to see the system as a compelling threat to Russian national security and the broader strategic balance between the US/NATO and Russia. At the root of this perception is a sense that the current iteration of the EPAA system is simply an early version of a more robust future capability, including, potentially, an offensive capability, that will pose a more pronounced challenge to Russian security and could violate the Intermediate Nuclear Forces (INF) treaty. After the completion of the Romania Aegis Ashore site in May 2016, President Vladimir Putin said: "At the moment the interceptor missiles installed have a range of 500km, soon this will go up to 1,000km, and, worse than that, they can be rearmed with 2,400km-range offensive missiles even today, and it can be done by simply switching the software."

Modernisation and coercion

In 2010, Russia began the State Armaments 2020 Program (SAP 2020), a massive effort to recapitalise around 70 per cent of Russia's armed forces by 2020, including modernisation and upgrading of Russia's missile forces. The programme originally allotted $600bn over 10 years, plus between $50bn-$100bn to upgrade the defence industry, according to *IHS Jane's Navigating the Emerging Markets: Russia*. The figures have been revised downward considerably and timelines have been extended. *IHS Jane's* estimates the new value of the investment at $350bn and the completion of the programme moved out to 2023, largely due to the combined effect of sanctions and lost revenues emanating from the volatility of the energy market.

Still, SAP 2020/23 is still investing in capabilities, many asymmetric in nature, that leverage the strengths of Russia's industry, are relatively cheap to build and deploy, and, according to Dr Stephen Blank, a senior fellow with the American Foreign Policy Council, can have an outsized disruptive effect on Western military capabilities. Tactical ballistic missile systems, such as Iskander M, RS-24 and Bulava, and strategic ballistic missile/strike systems – RS-26 Rubezh, RS-28 Sarmat, Project 4202 – were identified as priority categories of capabilities in which to invest, as were S-400 and S-500 air and missile defence systems.

That this investment in strike capacity coincided with the start of the finalisation of the EPAA is not a coincidence. In a January 2015 *Jane's Intelligence Review* article "Russia upgrades its missile arsenal", *IHS Jane's* analyst Sean O'Connor noted: "The upgrade programmes currently under way within Russia's strategic nuclear forces are in part

ACTIVE AND ANTICIPATED ELEMENTS OF THE EUROPEAN PHASED ADAPTIVE APPROACH (EPAA)

PHASE	TIMING	DESCRIPTION	COMPONENTS
Phase I	2011	■ Deployment of Aegis ballistic missile defense capable ships based in Rota, Spain ■ Deployment of AN/TPY-2 radar deployed to Turkey ■ Command, control, battle management and communications upgrades to Ramstein, Germany ■ Aegis ballistic missile defence ships	■ SM-3 Block IA interceptor ■ AN/TPY-2 radar ■ C2BMC upgrades ■ Designed to defend against short- and medium-range missiles
Phase II	July 2016	■ Deployment of Aegis Ashore at Deveselu, Romania	■ Aegis combat system BMD 5.0 ■ SM-3 Block IB interceptor ■ Designed to defend against short- and medium-range missiles
Phase III	Anticipated in 2018	■ Deployment of Aegis Ashore in Redzikowo, Poland in 2018	■ Aegis combat system ■ SM-3 Block IIB interceptor ■ Designed to defend against medium- and intermediate-range missiles
Phase IV	Cancelled in March 2013	■ Originally designed to provide a longer-range capability to intercept intercontinental ballistic missiles (ICBMs)	■ Aegis combat system in Deveselu, Romania and Redzikowo, Poland ■ SME-IIB missiles ■ Designed to defend against intermediate-range and intercontinental ballistic missiles

designed to offer new capabilities to counter US anti-ballistic missile (ABM) systems in Europe without violating the letter of the Intermediate Nuclear Forces (INF) treaty."

In addition to strategic and tactical ballistic missile programmes, Russia has, since 2004, invested in a hypersonic weapons programme known as Project 4202. Hypersonic glide vehicles travel at speeds between Mach 5 and 10. Dr Blank said: "[They] use sophisticated technologies for manoeuvring and boost that allow them to deliver warheads rapidly, evade defences and target precisely."

Russia is not the only country with a hypersonic weapons programme – the US and China have relatively mature projects – but Dr Blank believes Project 4202 is part of an effort to reinforce Russia's strategic nuclear deterrent, saying that the project is part of an "obsession – not too strong a word here ... to build supposedly invulnerable nuclear weapons, like hypersonics, that cannot be attacked by missile defences."

The capability is not expected to be deployed until possibly the early-to-mid 2020s, but clearly it is conceived of as another asymmetric means of bypassing European missile defence efforts and holding the West at risk. Boris Obnosov, director of the state-run Tactical Missiles Corporation, which is developing the Yu-71 hypersonic glide vehicle, told Russia's state news agency Sputnik in August 2016: "It's obvious that with such speeds – when missiles will be capable of flying through the atmosphere at speeds of seven to 12 times the speed of sound, all [air] defense systems will be weakened considerably."

Russia's enhanced missile and advanced capability programmes are also leveraged to deter and intimidate. For example, in May 2016, Russia announced it would deploy the Iskander M mobile short-range ballistic missile permanently to the exclave of Kaliningrad later this decade. The missile has been deployed to Kaliningrad twice previously, but only in support of exercises. The move was ostensibly in direct response to the opening of the first Aegis Ashore site in Romania, though many observers believe the Iskander would have been deployed to Kaliningrad regardless. For NATO, and especially the Baltic States and Eastern European allies, the announcement was provocative. With a range of up to 500km, all of the neighbouring Baltics, Poland – including Redzikowo, the site of the second Aegis Ashore system – and parts of Germany will be within range of the nuclear-capable SRBM. Fears that these states could become isolated and vulnerable are drawing a bold line under perceptions of the need for more robust missile defence capabilities and reinforcing the difficult to escape security dilemma unfolding in Eastern and Northern Europe.

Russian decline and durability

Russia's perceived strength demonstrated through its assertive foreign policy, military modernisation and advancement of its missile capabilities is driving the intensity and urgency of Europe's perception of the Russian threat. But it could be that underlying Russian weakness – demographic, educational, economic, civil society, political, in innovation – will ensure the durability and unpredictability of this perceived threat and the propensity for Russia to pursue risk-burdened and aggressive policies to distract or slow decline.

S Enders Wimbush, a long-time Russia/Eurasia analyst, SAFS Centre senior associate and director of the Russia in Decline programme at the Jamestown Foundation in Washington DC, has been examining the signposts and possible implications of structural Russian weakness. According to Wimbush: "Evidence of Russia's decline across every aspect of its power and authority is voluminous and compelling, and seasoned analysts in both the West and Russia itself are turning their attention increasingly to the kinds of dynamics decline could produce and possible contingencies flowing from these dynamics. Most Western policy makers and defense and security planners are stuck in the Russia-as-normal-country paradigm, but this ceased to be the case long ago."

Crucially, this weakness will engender behaviours that pose persistent challenges to Europe and the US over time, including using current and future air and missile capabilities to confront the West in Russia's "near abroad". To Wimbush, "a declining Russia which must take more risks to remain competitive is a serious challenge" for European and US security. ■

National missile defences in Europe

The way in which Germany, Poland, the Netherlands and Lithuania are bolstering their air defences provides a valuable insight into how current and emerging market dynamics, procurement priorities and capability requirements are developing

The missile threat to Europe is multi-dimensional and omnidirectional. NATO states will rely on the European Phased Adaptive Approach (EPAA) to meet the medium- and intermediate-range ballistic missile threats, but NATO members – as well as partners and non-members – are increasingly either actively seeking or investigating alternative national or regional solutions to meet the low-tier air and missile threats, as well as short-range air defence (SHORAD) and very short-range air defence (VSHORAD) missions.

As procurement competitions unfold in places such as Poland, Germany, Lithuania, Spain, the Netherlands, Romania, the Czech Republic, Georgia, Switzerland and Sweden (among others), they are revealing critical insights about the emerging competitive dynamics, future parameters and trajectories of what will be a very active market over the next five to 10 years. Four deals are particularly useful in understanding current and emerging market dynamics, procurement priorities and capability requirements.

Germany: TLVS

In June 2015, Germany announced that it had chosen to move forward with the Medium Extended Air Defence System (MEADS) International consortium (led by MBDA and Lockheed Martin) to meet its Taktisches Luftverteidigungssystem (TLVS) ground-based air defence system requirement. MEADS was chosen to replace Germany's Patriot air defence systems, originally fielded in the 1980s. Stated procurement requirements include: a fully-hemispherical 360-degree coverage; an open architecture to 'plug in and fight'; increased mobility, especially in terms of air transportation by the air force's A400M airlifter; as well as reduced crew and life-cycle costs.

The MEADS programme promised enhanced capability to meet longer-range and diverse threats through the implementation of the Lockheed Martin PAC-3 Missile Segment Enhancement (MSE) missile, the Multifunction Fire Control Radar (MFCR – an X-band, solid-state, phased array radar using element-level transmit/receive modules developed in Germany), the MEADS 360-degree ultra-high frequency (UHF) active electronically steered array radar, and MEADS BMC4I Tactical Operations Centre. For the TLVS program, MEADS has proposed to augment PAC-3 MSE with Diehl's IRIS-T-SLS as a notional low cost medium-range interceptor solution.

> "The TLVS is among the first major procurements in which the German government is employing a new process to limit risk to cost overruns and delayed delivery"

MEADS is still being developed, and Germany plans to continue to operate Patriot systems well into the next decade. Estimates for fielding the TLVS capability range from "around 2030", according to General Michael Grossmann, director of ground-based operations at German Air Force, to a June 2016 *Jane's Defence Weekly* assessment of "about 2025".

The deal underscores three notable market dynamics and potential emerging procurement priorities.

First, the estimated €4bn ($4.5bn) decision is a significant opportunity for the MEADS programme to establish itself in the highly-competitive international export market after a somewhat mixed history since 2011. The MEADS programme was formally established through a 2004 Memorandum of Understanding (MoU) between the US, Italy and Germany, with the intention of developing a novel system capable of meeting threats from tactical ballistic missiles, cruise missiles, unmanned aerial vehicles and aircraft. MEADS suffered a setback in 2011when the US Army ceased its participation in the programme, instead opting continued investment in Raytheon's Patriot systems. MEADS was subsequently restructured, enabling all three countries to harness and leverage the technology following the 2013 demonstration phase. Finalising the TLVS contract could serve as the life-line for the program, especially given the influence that the German defence market can have on many of its neighbours.

Second, the TLVS procurement is also notable because it is among the first major procurements in which the German government is employing a new process to limit government risk to cost overruns and delayed delivery. To retain the contract, MEADS must meet six milestones along what Rick Edwards, executive vice-president of Lockheed Martin's Missile and Fire Control division, referred to at the ILA 2016 exhibition in Berlin in June as "an ambitious timeline". "Lockheed Martin is 100 per cent committed to the success of the [TLVS-MEADS] programme and our partnership with MBDA," Edwards said.

A defence analyst speaking to *IHS Jane's* after the 2015 award, said German Defence State Secretary Katrin Suder "has initiated a change of paradigm" in German defence procurement to help mitigate risk. "The tactical air defence system is the first procurement programme based on firm milestones with an opt-out option in case the milestones are not met. It is against this background that the defence ministry will keep in contact with Raytheon, which offered an enhanced Patriot version. The MEADS Consortium has been given to understand,

Photography: Tech Sgt Brian Kimball/DoD/Flickr

Patriot missile batteries were deployed in Romania during a joint training exercise with the US on 7 November 2016

that the opt-out clause is for real," the analyst said. In a highly competitive market requiring heavy investment, a government's ability to play competing companies and their systems off one another, even after awarding a contract, could become a common way to help them drive down costs and gain a more reliable capability within a faster timeline.

It is already happening to a degree in Germany and, to a lesser extent in Poland, two competitions that demonstrate the "gloves off" nature of the air and missile defence competitions in Europe. During ILA 2016, Raytheon announced that it is in renewed discussions with Germany to potentially resubmit its Patriot ground-based air defence system for TLVS in case MEADS fails to meet the mandated milestones. Lockheed Martin and MBDA pushed back against the statement, responding that MEADS was on-course to meet the TLVS stated requirements. The exchange and continued engagement of both firms after award indicates the accelerating competitive dynamics in this market as all companies seek to either establish or expand user communities within Europe.

Third, the deal reflects the challenges associated with costs of advanced air and missile defence systems generally and still developing systems, in particular. MBDA Deutschland submitted its proposal for the development of TLVS to the German Federal Office of Bundeswehr Equipment, Information Technology and In-Service Support on 28 September 2016. The original goal was for MEADS and the German government to sign a contract in the first half of 2017 based on this proposal.

This timeline may be in jeopardy. Reporting from Reuters in October 2016 – citing "multiple sources familiar with the proposal" – indicated that the proposed MEADS cost was higher than anticipated. *IHS Jane's* analysts interviewed for this paper were unable to confirm Reuters' report, but did note that the cost of PAC-3 Missile Standard Extension interceptor was high and that, while the MEADS system has demonstrated capabilities in live simulations, the system still requires further development before being fielded that could also add previously unanticipated cost.

The German government has not responded directly to the report, commenting only that it is still evaluating the proposal. If contract signature pushes beyond mid-2017, it could conceivably be delayed further by Germany's federal elections, between late August and late October 2017.

Poland's Shield

On 21 April 2015, just weeks before Germany's TLVS announcement, then-Polish president Bronislaw Komorowski announced that Raytheon's Patriot missile system had been selected for the country's Wisla medium-range air- and missile-defence (AMD) system. Patriot was chosen over Eurosam's SAMP/T system in the final round of the competition.

After over 15 months of discussions, the Polish government confirmed it would move forward with the procurement of eight of the latest Patriot (Configuration +3) systems on 6 September 2016 at Poland's annual MPSO defence exhibition. All eight batteries are expected to be delivered by 2025. The Patriot systems will replace Poland's existing air-defence capabilities based on ageing Soviet-designed equipment. Estimates of the cost range from around $3bn-$5.6bn.

The award is a significant development for the Patriot system in a competition that had taken on increased urgency and political significance in the context of the Crimea and Ukraine crises and rising tensions between NATO and Russia.

The deal calls for the phased delivery of progressively advanced capabilities. The first two Patriot batteries will be "interim standard" of the Patriot (Configuration +3) and will be delivered in 2019. Two batteries featuring Raytheon's next-generation gallium nitrite (GaN) AESA 360-degree radar – a key requirement of the competition – are expected to be delivered in 2022. Four more systems will be delivered by 2025 at which point the two interim standard versions will be upgraded to the Wisla standard, according to *IHS Jane's*.

The procurement also calls for the incorporation of an open-architecture design that would allow for full operational compatibility with the Northrop Grumman Integrated Battle Command System (IBCS), further stressing the need for open architecture and the capacity to integrate new capabilities into existing systems. According to *IHS Jane's* reporting in September 2016, the IBCS system is not yet in service, thought it has successfully completed test firings. It is not currently exportable.

Another core component of the agreement is extensive industrial co-operation between Raytheon and the Polish defence industry. Raytheon has already signed agreements with PGZ, Poland's national defence industrial consortium, to build the identification friend or foe (IFF) modules for the AESA radars. Raytheon is also collaborating with Polish industry on the development and production of the SkyCeptor low-cost interceptor, one of four interceptors – PAC-2 GEM-T, PAC-3 and PAC-3 MSE are the others – offered as part of the procurement. SkyCeptor will leverage the Raytheon/Rafael Stunner missile design, though SkyCeptor will have some characteristics specially designed for the Polish threat environment, such as low-observability. Polish industry will be responsible for 50 per cent of the missile's production.

The Wisla procurement constitutes the low-tier component of Poland's plan for a layered air and missile defence system known as Poland's Shield. Poland is still considering options for the Narew programme, which will be designed to address short-range threats. Longer-range threats will be addressed by land-based Standard Missile-3 Blocks IB and IIA Aegis Ashore interceptors based at Redzikowo from 2018, as part of EPAA Phase III.

MEADS was originally eliminated prior to the downselect to SAMP/T and Patriot, but renewed discussions with the Polish Ministry of Defence in February 2016, nearly a year after the original Patriot announcement. While the discussions did not lead to a Wisla award, MEADS reportedly remains a candidate for the Narew procurement. Kongsberg's Norwegian Advanced Surface-to-Air Missile System (NASAMS), Barak 8 (also being offered for a Polish Navy requirement), Iron Dome/SPYDER, MBDA's MICA-VL and Diehl's IRIS-T-SLS are also contenders, according to *IHS Jane's* analysts.

Netherlands

In October 2016, the Netherlands chose to upgrade its Patriot systems with the Modern Man Station user interface. The deal guarantees that Dutch Patriot systems will be operational out to 2040. According to Robin Hughes, editor of *IHS Jane's Missiles and Rockets*, a key discriminator in the procurement was Raytheon's ability to offer the Netherlands a complete re-capitalisation of their Patriot systems due to funding received from "Patriot sales to South Korea and the UAE", highlighting the value of large user communities in defraying costs of system upgrades.

The Netherlands currently fields the PAC-3 and PAC-2 ABM missiles for its system and is also considering procurement of a low-cost interceptor such as Stunner/SkyCeptor or Diehl's IRIS-T. Some reports indicate Lockheed Martin's PAC-3 MSE is also being considered for the Netherlands' Patriot batteries.

Lithuania

Lithuania's decision to acquire two batteries of the Norwegian Advanced Surface-to-Air Missile System (NASAMS) from Norway in October 2016 demonstrates the urgent perceptions of the Russian threat in the Baltics. It also serves as a catalyst for discussion of a Baltics-wide air and missile defence system or new operational concepts for the deployment of low-tier integrated air and missile defence systems from other NATO states. The NASAMS systems are expected to be delivered in 2020 and, according to *Jane's Defence Weekly*, will "offer a step-change in air defence capability for the Lithuanian Armed Forces". Latvia is also reportedly receiving older NASAMS systems from Norway, and multiple *IHS Jane's* analysts have suggested that over the next few years the Baltic States may consider "clubbing together to buy a true medium-to-long range (70km+) air-defence system, such as the Patriot", according to recently published analysis from Nick de Larrinaga, Europe and CIS editor at *Jane's Defence Weekly*.

While the costs of advanced missile defence systems are notoriously high, circumspection of Russia in the Baltics has driven dramatic rises in defence budgets across the region that could enable such a combined procurement of an advanced system. Craig Caffrey, principal analyst on *IHS Jane's* Defence Industry and Budgets team noted in October 2016 that "the profile of defence spending [in the Baltics] has changed dramatically in the last two years. Their defence budgets will all be over 2 percent of GDP by 2018, and each country will have doubled or tripled their budgets from 10 years ago. In 2005, the region's total defence budget was $930m. By 2020, the region's defence budget will be $2.1bn. This growth is faster than any other region globally."

Even if such a procurement does not happen, or alternatively if an enhanced air and missile defence requirement becomes more prominent in the short-term, other NATO nations may choose to deploy their own national systems to the Baltics. In fact, Germany and the Netherlands have discussed this contingency as part of their ongoing Patriot interoperability program known as Project Apollo. ■

Concepts, tensions and requirements

Threat and market environments are challenging end-users and air and missile defence system manufacturers as they seek to balance the key concepts, tensions and emerging requirements shaping the future of European defence

The missile-versus-missile defence competition is among the most acute examples of the cost-imposing challenges of the diffusion of advanced military, commercial and dual-use technology. The costs of resilient, adaptive and layered missile defence systems are considerably more expensive to develop, test and maintain than the cost of developing a viable cruise and ballistic missile threat. One *IHS Jane's* expert referred to the cost for the highest-end interceptors on the market today as "eye-watering".

Emerging low-cost-of-shot/deep-magazine solutions, such as directed energy and hyper-velocity projectiles fired from naval powder guns, operational concepts (left-of-launch interventions, for example) and competitive strategies designed to minimize the need for intercepts in the first place offer some promise in changing current cost curves. However, these capabilities and concepts are not yet mature, and the path from concept to deployment of new technologies and concepts is longer, harder and more expensive than fully appreciated when concepts are being initially trialled or explored. Expensive kinetic interceptors will remain the anchor of the missile defence solutions well into the next decade.

Within the European context, the budgetary environment has improved since the low point of 2014 when *IHS Jane's Defence Budgets* assessed that NATO accounted for 12 of the 20 fastest declining defence budgets in the world. As captured in the charts below, spending across most of the continent is increasing, especially in Eastern Europe and the Baltic States. Indeed, Chris Lombardi, vice-president for European Business Development at Raytheon, told *IHS Aerospace, Defence and Security* that he had seen a "very strong recent push by countries and leadership to increase budgets and develop solutions to meet the expanding threat environment."

Even with these budget increases, cost will remain an important – though not necessarily prohibitive – factor in the procurement of air and missile defence programmes as states across the continent grapple with how best to prioritise spending in a full threat environment. Even in countries such as Poland, where the sense of threat is largely focused on Russian activity and capabilities, analysts believe the expanding requirements are outpacing expanding budgets. As *IHS Jane's* contributor Reuben Johnson pointed out in his *Jane's Defence Weekly* coverage of the September 2016 MSPO defence exhibition in Poland. He wrote: "The projected cost of all the systems Poland plans to procure is more than twice what the country's Finance Ministry has projected in terms of future tax revenues."

> "Expensive kinetic interceptors will remain the anchor of the missile defence solutions well into the next decade"

The result of this tension is a market that is still active, but will need to be responsive to evolving and expanding air and missile threats while also seeking to manage potentially spiralling costs of layered, interoperable, adaptive, and flexible air and missile defence systems.

Procurement of air and missile defence systems is not the only cost end-user communities incur, of course. Operating and maintaining these systems is a concern to end-user communities, particularly costs associated with transporting systems to where they are needed, training programmes, exercises, upgrading to incorporate new generations or capabilities, depot maintenance and the manpower to actually operate a system.

Layers and interoperability

A recurring theme throughout this paper is the need for layered air and missile defence systems. From Israel, UAE and Qatar to South Korea and Japan to Poland, Germany, Romania and the Netherlands, defence communities are investing in multiple systems to optimise existing capabilities and ensure redundancy against multiple threats along multiple axes and from multiple directions at multiple speeds and traveling multiple distances.

However, developing and deploying multiple layers of missile defence is not cheap or easy, placing a premium on high degrees of integration of and interoperability in and among various layers in national and multi-national systems. This frequently requires the enhancement of open architectures – an increasing requirement for missile defence systems across Europe – that allow for "plug-in and fight" interoperability between multi-national systems or, even, as with the Poland Wisla procurement, between different missile defence components manufactured by different companies.

Bi-lateral and regional collaboration efforts are ongoing. For example, in October 2016, Germany and the Netherlands tested joint operations of their Patriot systems during an exercise off the coast of Crete, as a part of a programme known as Project Apollo. During a speaking engagement at the European Integrated Air and Missile Defence Conference in London in February 2016, Brigadier General Michael Grossmann, director of ground-based operations with the German Air Force, noted that the programme could be a model for multi-lateral deployments to Poland or the Baltic States in the future. According to Brigadier

General Grossman, the programme is "also hoping to open up Apollo to other European countries to allow them to bring their capabilities to the project".

But the appropriate and admirable ambition of Project Apollo should be tempered to a degree by the recognition that achieving an operationally effective bi-lateral or multi-lateral "plug-in and fight" interoperability can be a complicated task.

In October 2015, eight member nations of the Maritime Theatre Missile Defense Forum held the At Sea Demonstration 2015 (ASD 2015) exercise on the Hebrides Range off the coast of Scotland. The "landmark" exercise was first multi-national Integrated Air and Missile Defense (IAMD) test and, according to Richard Scott, *IHS Jane's Naval* contributor, "the most technically complex naval live-firing event ever attempted in Europe."

The exercise achieved several tactical and operational successes, but it also exposed persistent challenges related to "plug-in and fight" interoperability and establishing robust network links for real-time tactical data exchange. At the MAST 2016 conference in Amsterdam in June 2016, Commander Andreas Ulm, ballistic missile defence project officer in the German Navy headquarters and ASD15 chief of staff, noted: "I didn't fight the enemy most of the time, but I fought our interoperability issues." Commander Ulm continued: "What ASD15 proved to me was that 'plug-in and fight' is just a dream, unless you are on an Aegis destroyer in a well worked–up Aegis task group ... But again, it was not 'plug-in and fight."

> "What ASD15 proved to me was that 'plug-in and fight' is just a dream, unless you are on an Aegis destroyer in a well worked–up task group ..."

Immediate threat

The air and missile defence threat facing Europe is neither notional nor distant. Enhancement, development and proliferation of air breathing and ballistic threats is happening now and are playing a more consequential role in intensifying regional geopolitical competitions, especially with Russia.

Developing, acquiring and deploying individual systems – much less layered systems – takes years. The TLVS (2025-30), Wisla (2019 before the initial Patriot is deployed, 2025 before the final system is active), and the Lithuanian NASAMS procurement (2020) all progressed in the 2016 strategic context, but are unlikely to be fielded until next decade, creating a potentially destabilising imbalance between the immediacy of a more robust threat and the ability of states in Europe to field the right capability to directly address the threat and avoid coercion, manipulation or a kinetic strike in a time of crisis.

Some of this potential vulnerability has been met through the signing of procurement and/or upgrade deals with "name brand" US and European suppliers with proven capabilities that will shorten these windows of strategic vulnerability. This was almost certainly a powerful consideration in Poland's decision to move forward with Patriot for its Wisla requirement. As a defence analyst based in Warsaw noted to *IHS Jane's* after the April 2015 announcement of Patriot's selection, "after Raytheon's business development team, the person perhaps most responsible for Raytheon's win in Poland is Vladimir Putin. Otherwise the Poles might have been willing to go with another system with a longer procurement timeline that allowed them to be involved in the design from the ground up."

One important caveat: a key discriminator for all industry seeking to be successful in the European air and missile defence market, especially in states seeking to upgrade

EASTERN EUROPE DEFENCE EXPENDITURE

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Poland	7,449	7,715	7,365	8,295	9,852	9,181	9,391	9,758	10,147	10,488
Greece	3,538	3,423	3,742	3,102	2,862	2,718	2,660	2,676	2,706	2,736
Romania	2,076	2,031	2,092	2,648	2,662	3,083	3,480	3,925	4,147	4,266
Ukraine	1,023	1,226	1,098	1,699	2,332	2,427	2,379	2,348	2,353	2,378
Czech Republic	1,804	1,762	1,680	1,638	1,686	1,829	2,027	2,246	2,496	2,766
Hungary	1,019	972	932	934	947	1,108	1,161	1,210	1,310	1,423
Slovakia	788	830	759	787	921	918	959	995	1,035	1,077
Croatia	733	664	664	591	589	583	572	591	614	639
Bulgaria	558	547	604	570	538	623	680	668	662	706
Serbia	751	512	527	544	493	484	482	494	517	550
Lithuania	302	293	306	327	446	599	680	740	790	841
Estonia	322	381	389	405	430	468	481	491	500	518
Slovenia	501	375	369	355	344	363	353	366	379	396
Latvia	246	259	256	236	265	384	486	597	614	630
TOTAL	21,111	20,991	20,782	22,132	24,365	24,768	25,791	27,104	28,271	29,414

Source: Jane's Defence Budgets

WESTERN EUROPE DEFENCE EXPENDITURE

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
United Kingdom	63,648	62,732	60,968	60,734	60,662	60,945	60,765	60,615	60,673	60,822
France	43,896	44,159	44,924	44,407	44,338	44,877	45,287	45,687	45,866	45,856
Germany	35,788	35,718	36,480	35,199	35,906	35,754	37,539	37,208	37,626	38,395
Italy	23,612	23,407	24,377	23,601	22,986	23,055	22,253	21,927	22,002	22,299
Spain	13,360	12,016	11,043	10,934	10,991	11,008	11,207	11,312	11,402	11,587
Netherlands	9,293	8,816	8,352	8,295	8,443	8,586	8,595	8,464	8,288	8,068
Switzerland	6,308	5,993	6,099	6,208	6,125	6,161	6,156	6,178	6,189	6,216
Sweden	5,495	5,602	5,533	5,754	5,679	5,687	5,788	5,827	5,987	6,127
Norway	4,777	4,771	4,842	4,878	5,120	5,824	5,937	5,913	5,886	5,836
Belgium	4,180	4,083	4,040	3,805	3,511	3,460	3,467	3,526	3,646	3,782
Denmark	3,633	3,576	3,490	3,297	3,021	2,997	3,043	2,961	2,904	2,972
Finland	3,277	3,174	3,124	2,939	2,826	3,009	3,022	3,022	3,243	3,338
Portugal	2,275	2,267	2,255	2,079	2,060	2,038	2,049	2,071	2,126	2,224
Austria	2,319	2,323	2,183	2,084	1,942	2,277	2,322	2,319	2,324	2,322
Ireland	1,056	1,017	1,004	999	958	942	908	885	880	863
TOTAL	222,916	219,656	218,713	215,213	214,568	216,620	218,339	217,915	219,041	220,707

Source: Jane's Defence Budgets

old Soviet equipment and improve domestic industry in the process, will be the capacity of firms to partner with and provide meaningful workshare to local industry in procuring states and maintain a viable supply chain across Europe. Poland's Wisla procurement included an extensive role for Polish industry in the co-development of the SkyCeptor LCI and GEM-T missile systems and in the production of ancillary system, such as contributions to wheeled vehicles, for the Patriot systems.

But industry engagement adds a layer of complexity to closing the gap between threat and capability that could introduce risks for both industry and for end-user communities. For industry, the need to have a comprehensive understanding of local industry strengths, weaknesses, relationships, opportunities and challenges and to develop and operationalise effective strategies for engagement of partners and suppliers in country is a critical consideration for market entry. This is especially the case in the air and missile defence market in which, as discussed above, savvy buyers will have many options and expect rapid delivery of reliable capability. Sticking to timelines will be critical. Many local firms may not be able to absorb relevant technologies or, alternatively, because only some firms can absorb these technologies they will have relationships with other foreign suppliers on related programmes. Delays to post-award development timelines and unintended diffusion of critical technologies are both possible.

For end-user communities, even moderate delays to timelines can be worrisome, reinforcing the sense of urgency of the need to begin procurement programmes, even if the capabilities will not be fielded for another decade.

Adaptive capability

In his remarks initially announcing the US intention to pursue the EPAA in September 2009, President Barack Obama said: "Because our approach will be phased and adaptive, we will retain the flexibility to adjust and enhance our defences as the threat and technology continue to evolve."

The need to affordably augment or upgrade a current system with new technologies and capabilities is not unique to EPAA. It is a central requirement for air and missile systems at all levels, given the interactive and shifting nature of the competition between emerging offensive and defensive air and missile capabilities and the pace at which new technologies and operational concepts are proliferating.

Some end-user operational requirements are already known and are influencing requirements of current and imminent competitions. In addition to the growing interest in open architectures and ability to reduce operational costs, three additional requirements stand out as relevant over the next five to 10 years.

■ **Missile mixes and low-cost interceptors:** The cost of kinetic interceptors is one of the main drivers of the high costs of air and missile defence systems. Not only are the handful of high-end interceptors on the market expensive, users frequently need to procure many of these systems in order to ensure adequate redundancy.

But not all threats require high-end interceptors. Using an SM-3 Block IIA or PAC-3 MSE against lower-tier, but diffused and still menacing, threats, is not an effective way to optimize air and missile defence investments. A more modular "horses-for-courses" approach that enables systems to use a wider-range of missile types to meet a wider-range of threat types is one effective means of balancing the need for a flexible capability while managing procurement and operational costs.

The highly-sophisticated technologies of the kind used on the PAC-3 MSE will be part of this mix for countries building defences against sophisticated theatre ballistic missiles. But air and missile defence systems will be required to be able to accommodate less expensive systems, such as the

GEM-T, and low cost interceptors, such as Diehl's IRIS-T-SLS and Raytheon/Rafael's Stunner, the model for the made-in-Poland SkyCeptor, which will be used in Poland's Shield Patriot systems.

■ **360-degree radar:** Guided missiles, low observable aircraft and the proliferation of unmanned systems all serve to expand the geographic range that militaries must plausibly monitor for air and missile threats in times of crisis. Militaries cannot necessarily assume with a high degree of certainty the nature of attack vectors against them, creating growing demand for fully-hemispheric 360-degree coverage for missile defence.

This was a stated requirement for the large deals unfolding in Germany and Poland. The still in-development MEADS system will include a 360-degree UHF active electronically steered array radar when it is scheduled to come online in 2025-30. Neither the current generation of the Patriot nor the SAMP/T systems considered by Poland offered 360-degree capability. However, the next generation Patriot system selected by Poland will add this capability through upgrades and the incorporation of rear panels that utilize "staring" arrays.

Regardless of the particular approach, being able to field a reliable and affordable 360-degree capability will be a significant discriminator in the market.

■ **Incorporating novel emerging technologies:** Perhaps the most notable component of the AESA next generation Patriot radar offered to Poland is its use of gallium nitride (GaN) one of many novel emerging technologies likely to affect the future of the air/strike versus missile defence competition.

According to a September 2015 *IHS Jane's Intelligence Briefing* webinar on GaN technologies, the technology provides considerably more thermal conductivity than gallium arsenide (GaAs) as well as higher-power, improved reliability, range and affordability. The technology is particularly relevant to the radar market as it offers greater power density, improved efficiency and facilitates the development of new equipment and upgrades to existing AESAs. *IHS Jane's* analysis also stated that GaN would "rejuvenate the radar market for years to come".

GaN technology is also now being incorporated into radars, electronic warfare and communications systems. Several companies, particularly those in the US, now offer GaN technologies in multi-role radars, including Northrop Grumman (G/ATOR) and Lockheed Martin (TP-77). Raytheon — which according to Lombardi, has invested over $300m of its own money into GaN research – operates the only US Department of Defence certified GaN foundry.

GaN is just one – albeit immediately relevant – critical technology impacting the future of missile defence. There are many others. In the diverse, dynamic and durable threat environment described above, industry will be pressured to develop, test and field new and relevant technologies as they come available in order to mitigate new threats and also, potentially, drive the missile-versus-missile defence competition along a new trajectory.

> "Common training, similar depot maintenance and joint exercises also help reduce manpower and overall operational costs"

Customers and user communities

The air and missile defence market is already very competitive and will become more so as states in Eastern Europe and the Baltics seek to upgrade old Soviet equipment and states in Western Europe look to procure more robust layered missile defences or upgrade existing systems to meet new threats.

Companies are increasingly seeing the advantage of commonality and momentum as powerful discriminators in this market environment and are therefore trying to establish anchor clients that can open doors to additional markets, prioritising interoperability with their neighbours. The end-goal is a chain reaction (or series of them) in which successive states linked by proximity and shared threat perception select a similar or complementary capability, ensuring "user communities" that help defray operational and engineering upgrade costs across multiple users. As Lombardi noted, one of Patriot's main selling points in the current market is that "operational engineering upgrade costs are shared across a user-community of 14 nations – including five NATO members. Common training, similar depot maintenance and joint exercises also help reduce manpower and overall operational costs."

Of course, Raytheon isn't the only company seeking to develop these communities. Capital Alpha, a firm monitoring defence developments for the financial services industry, identified the importance of anchor clients and user communities to both industry and national militaries in its October 2016 coverage of an Atlantic Council event on "The Future of US-Swedish Defense Co-operation." The report noted: "Air defense system commonality with Poland, Sweden and Germany remains an intriguing prospect. It's why the stakes remain high for Lockheed Martin to have MEADS procured by Germany, as that might also raise prospects for Sweden. Equally, if Raytheon can keep Poland in Patriot and MEADS proves unaffordable for Germany, it can offer upgrades to existing German Patriot unity, and that would also enhance prospects for Sweden."

Conclusion

Europe's threat environment is expanding; its geopolitical and political context growing more complex and competitive. Developing and deploying resilient, robust and affordable capabilities to address the full spectrum of security challenges will require a high-degree of cross-NATO and multi-national collaboration, co-ordination, commonality and co-operation. It will also require an effective diagnosis and prioritisation of emerging threats. This is especially the case with meeting air and missile threats and the coercive diplomacy they can enable. Defence communities and industry must find means of balancing cost while incorporating layered, interoperable, adaptable and, critically, demonstrated air and missile defence systems capable of deterring, dissuading and defeating the probable and possible threats of today, tomorrow and an increasingly anxious, contested and uncertain future. ■

Tate Nurkin, the Senior Director of the SAFS Centre, managed the production of this report. For more information about the SAFS Centre, please visit: www.ihs.com/Info/0116/safs.html