Istituto Affari Internazionali

Europe's Missile Defence and Italy: Capabilities and Cooperation

edited by Alessandro Marrone and Karolina Muti

ABSTRACT

Europe's missile defence is structurally linked to NATO deterrence and defence architecture, and it has to face both a worsened international security environment and an accelerating, worldwide technological innovation. Russia and China are heavily investing in new hypersonic systems which dramatically decrease the time needed to reach the target by flying mostly within the atmosphere. The US remains a global leader in the development and deployment of missile defence capabilities, including the Aegis systems which represent the cornerstone of NATO integrate air and missile defence covering the Old Continent. European countries are increasingly collaborating within the EU framework on the related capability development, primarily via the TWISTER project under the Permanent Structured Cooperation (PeSCo). Being exposed to missile threats from Middle East and North Africa and participating to allied nuclear sharing, Italy has a primary interest in upgrading its military capabilities through PeSCo, maintaining them fully integrated within NATO, and involving the national defence industry in cutting-edge procurement programmes.

Defence | Technology | Procurement | NATO | US | European Union | France | Germany | Italy | Poland | Turkey | United Kingdom

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Executive summary

The present study addresses Europe’s missile defence. A multi-level perspective is adopted touching on various aspects and providing a comprehensive overview of the topic. Ranging from capabilities’ state of the art and future developments, to the transatlantic strategic framework and main cooperation programmes, several key factors are considered. Europe’s missile defence does not operate in a vacuum and is inextricably related to NATO’s deterrence and defence architecture, Emerging and Disruptive Technologies (EDTs), and offensive capabilities of its competitors. For this reason, the study takes into consideration the most relevant Allies in terms of missile defence capabilities, but also technology innovation, the state of the art outside NATO’s perimeter, international treaties and regimes for arms control. The analysis is articulated in 13 sections, and particular attention is given to Italy and to the developments that are of interest for Rome.

The importance of missile defence for Italy and Europe

Section 1 provides an introduction to the rationale of missile defence in the rapidly changing international security environment. Its role in the national, European, and transatlantic framework is affected by global trends, such as the weakening of multilateral institutions, globalisation, the progressive loss of technological edge by the West, and the emergence of a variety of non-state actors that influence international relations. Against this backdrop, Italy’s national interests and threats to them call for a more in-depth assessment of missile defence capabilities and the role that they should play in the security architecture, nationally and at the EU and NATO levels.

Technological innovation and Euro-Atlantic industrial landscape

Section 2 analyses technological innovation with a focus on Ballistic Missile Defence (BMD) capabilities. The challenge posed by Delivery Systems (DSs) capable of hypersonic flight is not entirely new, but where the emerging new class of weapons differs is that most of the flight is within the atmosphere, thus dramatically decreasing the time needed to reach the target. At the same time, the Yemeni Civil War is illustrative of how the use of ballistic missiles is becoming normalised even in proxy wars, with the related technologies being within the reach of a variety of actors. The Section looks at technological solutions necessary to the detection and destruction of a ballistic threat, from pre-launch to midcourse, to terminal engagement. In this sense, cruise missiles, from subsonics to hypersonics, complicate the threat picture for effective defence. As a result, a layered approach is considered to constitute the most effective defensive posture. Against this backdrop, the Permanent Structured Cooperation (PeSCo)’s Timely Warning and Interception with Space-based Theater Surveillance (TWISTER) project is relevant, as it intends to develop an endo-atmospheric interceptor to engage intermediate- and medium-range ballistic missiles, hypersonic glides and systems.

Missile capabilities outside NATO

The topic of missile defence cannot be properly addressed without taking into consideration what offensive capabilities are available to competitors. Section 3 thoroughly outlines seven countries beyond NATO's perimeter, by summarising ballistic and cruise missile capabilities of seven countries, namely China, India, Iran, Israel, North Korea, Russia, and South Korea. A key, general point is that ballistic missiles are valued because they can deliver a relatively large warhead across borders to great distances in a short time; they can be launched with little or no warning, fly to their assigned targets autonomously, and penetrate all but the most sophisticated defensive systems. In this context, the Russian Federation has maintained an outstanding arsenal going through robust modernisation and upgrade, and currently works on hypersonic missiles with a rather confrontational attitude towards the West. Moving East, the strategic calculus behind China's no-first-use pledge may be altered due to the developments in the long-range strike capabilities of the United States, as evidenced by recent Beijing's statements and investments. For non-nuclear weapons states such as Iran, ballistic missiles provide an extra-territorial strike option and an alternative to advanced aircraft, which Tehran has not been able to afford or obtain because of international sanctions. North Korea viewed ballistic missiles similarly before becoming a nuclear-weapon state and therefore adding a further, nuclear importance to missiles as delivery systems.

Europe's missile defence: NATO role and EU contribution

Section 4 addresses Europe's missile defence by looking at the fundamental role played by NATO and at the EU contribution. The Alliance's Integrated Air and Missile Defence (IAMD) encompasses BMD and is aimed at the protection of both European territory, as a matter of collective defence, and allied forces deployed in operational theatres from short- and medium-range ballistic missiles. As far as NATO's BMD in Europe is concerned, its main pillar is the US' European Phased Adaptive Approach (EPAA), with the American Aegis Ashore system deployed in Romania and Aegis BMD-capable ships in Spain, the radar system based in Turkey, and the Command and Control (C2) infrastructure located in Germany. In the next years, Poland will host an Aegis Ashore missile system, too. In the second part, the Section offers an overview of EU programmes contributing directly or indirectly to missile defence in Europe, from the aforementioned TWISTER to the European Military Space Surveillance Awareness Network (EU-SSA-N). The former is probably the most interesting development at the EU level, since it sees the participation of the most capable EU member states in the defence field, namely France (project leader) Germany, Italy, Spain, Finland and the Netherlands. The system will contribute to both NATO's IAMD and European strategic autonomy in this field, increasing interoperability among Allies whilst sharing costs. TWISTER should be ready for service entry by 2030.

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France

Moving to the national case studies, for a long time France perceived the concept of missile defence essentially from a strategic angle, mainly within the framework of the balance between nuclear powers. Nowadays, the French posture has considerably evolved. France is one of the countries in Europe with the greatest expertise on the subject, in terms of both technology and industrial know-how, as well as military concepts. Noticeably, in operational terms, missile defence is under the sole authority of the Air Force. On a political level, while recognising the US’ essential role for Europe’s comprehensive missile defence, France would strive for an architecture where European authorities and industries retain control. The Section also gives an overview of the systems in use, concentrating on the Surface-to-Air Missile Platform/Terrain (SAMP/T) system’s role in French missile defence. SAMP/T is an air defence and anti-ballistic weapon system, whereas the Principal Anti-Air Missile System (PAAMS) – developed together with Italy and the United Kingdom (UK) – is effective against anti-ship missiles but does not have anti-ballistic capabilities. SAMP/T and PAAMS quite precisely reflect the French approach to missile defence.

Germany

As a legacy from the Cold War, Germany traditionally holds a strong position in NATO’s IAMD architecture, i.e. by hosting the Allied Air Command at the Ramstein base, which is in charge of NATO’s IAMD systems by incorporating data from airspace surveillance radars all over the Alliance’s territory, and providing air C2 and BMD capabilities. Yet, so far Berlin has mainly taken political action on the arms control dimension, through diplomatic efforts to devise new agreements on that topic. Regarding capabilities, Germany’s current focus lies on the tactical air and missile defence system (*Taktisches Luftverteidigungssystem* - TLVS) to replace Patriot. Meanwhile, the six ships of the next generation of F-127 frigates are planned to eventually replace aging F-124 Sachsen-class air defence frigates of the German Navy, and they are designed to fulfill all endo-atmospheric missile defence tasks, including addressing hypersonic missiles. Germany is also in the process of building up its first space-based early warning and target designation system for missile defence. Against this backdrop, its interest in the TWISTER project may pave the way for relevant developments with European partners.

Italy

Italy’s protection of the national soil is particularly difficult because of its proximity to North Africa and the Middle East, also given that Rome fell gradually within the reach of Iranian missiles, and that the Libyan arsenals have been smuggled after 2011. Moreover, Italy is one of the few European nations hosting US tactical nuclear weapons, and this makes the country a possible target by default of Russian potential missile attacks against American dual-capable bombers. Last but not least, Rome is one of the largest contributors in terms of personnel to NATO (first one after the US), EU and United Nations missions, and some of these operational

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theatres – e. g. Iraq – are highly subject to missile threats. However, missile defence has not enjoyed a high priority at the politico-strategic level, with a negative impact on the status of missile defence capabilities across the Armed Forces – which also suffer from a relative weakness of the joint level. The most important missile defence systems include the SAMP-T, developed through a cooperative programme with France, the PAAMS, resulting from cooperation with Paris and London, the Surface Anti-Air Missile/Extended Self Defence (SAAM/ESD), used on European Multi-Purpose Frigates (*Frégate Européenne Multi-Mission* - FREMM), whereas the Common Anti-air Modular Missile Extended Range (CAMM-ER) is a system currently in the procurement phase. Leonardo and MBDA Italia have been involved in these and other programmes in this field. The Italian capabilities are interoperable with NATO's IAMD, and Italy is among the first European countries to host a component of the new Allies C2 architecture as validating nation, at the Poggio Renatico command.

Poland

Poland's geopolitical position makes it particularly exposed to traditional security threats, especially considering recent modernisation of the equipment deployed in the Russian Kaliningrad enclave. Currently, Polish Air and Missile Defence (AMD) systems are Soviet-era equipment. Therefore, Warsaw is pursuing an ambitious Technical Modernisation Plan for 2021-2035, and AMD is among its key investment priorities. Wisła and Narew programmes are the most relevant in this domain, with the former aimed at defending the territory against tactical short-range ballistic missiles, cruise missiles, manned aircrafts, as well as Unmanned Aerial Vehicles (UAVs). The latter should be the core of Polish future AMD. As part of the NATO BMD architecture, as mentioned before, Warsaw will host the US Aegis Ashore component. However, all these programmes are experiencing considerable delays, and the Covid-19 pandemic will challenge the acquisitions further.

Turkey

Turkey's neighbourhood is particularly troublesome, with direct challenges posed by Syria and Iran. The acquisition of the S-400 missile defence system from Russia is the most interesting and serious development of Turkish defensive strategic weapons agenda. The acquisition is object of a heated debate, since the Russian product will not be compatible with Ankara's systems embedded in the NATO architecture, and it is likely to trigger the sanctions envisioned by the US Countering America's Adversaries through Sanctions Act (CAATSA). The CAATSA measures could even be tougher with the Joe Biden presidency. In recent years, Turkish military-industrial capacity has registered an exponentially growing number of indigenous and cooperative projects. Through expeditionary military campaigns in Syria, Turkey's defence industries have showcased reliable weaponry in action under real war-fighting conditions. Ankara's long-term strategic planning facilitated a rich military modernisation agenda, which currently faces difficult choices with respect to Russian suppliers and NATO Allies.

The United Kingdom

UK policymaking with regards to missile defence has been characterised by a historic ambivalence regarding both its utility and desirability for homeland BMD, especially since the UK's nuclear deterrent was deemed sufficient. London has carefully edged between the Alliance framework and a bilateral cooperation with the US. The UK currently contributes to 10 per cent of the costs of NATO missile defence, including the Active Layered Theatre Ballistic Missile Defence (ALTBMD) C2 structure and Alliance's Aegis Ashore sites, and is committed to build a ground-based UK missile defence radar. The movement of control over British joint Ground Based Air Defence (GBAD) capabilities, from the Royal Air Force (RAF) to the Army's 7th Air Defence Group, is indicative of a growing understanding of the threat faced by manoeuvring ground forces by, among others, cruise missiles. The potential for the UK's Type-45 destroyer to play a BMD role through PAAMS co-developed with European partners would benefit both NATO's BMD and the EU-UK defence industry relation after Brexit. London is also going to procure the CAMM-ER system developed by MBDA in concert with France and Italy.

The United States

The US is a global leader in the development and deployment of AMD systems. Its layered BMD is the most comprehensive currently deployed in the world, including multiple components such as the Ground-based Midcourse Defense (GMD) system, the Aegis, the Terminal High Altitude Area Defense (THAAD), and further upgrades of the Patriot. The US has also sought to strengthen the missile defence capabilities of its allies and partners. Through the direct deployment of EPAA in the Old Continent, Washington contributes to NATO's IAMD with the only element capable of providing wide-area defensive coverage of Europe. The emergence of new hypersonic weapons prompted the US in pursuing two counter-hypersonic programmes. On the one hand, the Missile Defense Agency's (MDA) Hypersonic Defence Regional Glide Phase Weapon System (RGPWS), which seeks to develop and mature the technologies necessary for a hypersonic defence system. On the other hand, the Glide Breaker programme within the Defense Advanced Research Projects Agency (DARPA).

Treaties and control regimes

Section 12 presents an overview of the main treaties and arms control regimes that regulate missile systems. Major bilateral or multilateral efforts such as the Missile Technology Control Regime (MTCR) have been undertaken to discourage the spread of sensitive materials and technologies necessary for the development of missiles and other DSs. While the instruments deriving from such efforts are mostly voluntary, they serve – or have served – as important Transparency and Confidence-Building (T&CB) measures among missile powers often equipped with nuclear weapons. The Anti-Ballistic Missile (ABM) Treaty and the Intermediate-Range Nuclear Forces (INF) Treaty have been playing for decades a pivotal role for Europe's strategic stability. Their demise leaves the Euro-Atlantic area in a

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dangerous limbo. The last pillar of bilateral arms control agreement is the New Strategic Arms Reduction Treaty (New START), renewed in 2021 by the US and Russia for another five years. A reflection is needed on how to complement it with other arrangements aimed to tackle the current technological innovation and great power competition.

Ten key points for Italy's approach

In light of the worsening missile threats, including the development of hypersonic weapons, and the various developments in the Euro-Atlantic landscape, the following ten key points should influence Italy's approach to missile defence.

First, NATO remains the strategic and operational cornerstone of Europe's missile defence, and this task is going to gain further relevance within the Alliance's renewed focus on collective defence and nuclear deterrence. Therefore, Italy's efforts should always be coherent with allied IAMD architecture and the requirements laid down through the NATO Defence Planning Process (NDPP). At the same time, Rome should insist on involving EU institutions in the NDPP in order to ensure more coherence between the respective visions, requirements and investments.

Second, European cooperation, mainly but not only through EU defence initiatives, has become the main channel to develop robust missile defence capabilities in a more effective and sustainable way. As a result, Italy should plan capability development and industrial policy in this field, primarily looking for cooperation with major European allies – namely France, Germany, and possibly the UK and Poland – and preferably using tools provided by PeSCo and European Defence Fund (EDF). Accordingly, Italy should commit adequate resources on TWISTER as a flagship project with France and Germany, but also on all related PeSCo initiatives, and particularly in the space domain. In a similar vein, Rome should look at EDF calls in a proactive, timely and comprehensive way, to decide priorities and co-funding. These resources should be coupled by a political, diplomatic and military effort to move European defence cooperation forward, as the only way to deliver adequate capabilities which no single country in Europe can afford on its own.

Third, in order to address current and upcoming missile threats, a range of sensors is required to find, identify and track hostile missiles. These ideally will include a space-based launch detection capacity combined with space-based, ground-based and ship-borne radars, also for early warning and for in-flight tracking and target discrimination, while a digital battle management backbone will be also needed. Actually, the radar systems, sensor suites, C2 and battle management systems do represent a relative strength of Italian defence and technological industrial base on which to build. Here, an elevated level of operational and technological sovereignty should be maintained in Italy. At the same time, interceptors represent a sector where Italian players made substantial progresses and, in this context, cooperation should be sought with France in order to develop together next generation effectors.

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Fourth, the space dimension of missile defence represents a promising and growing field. Constellations of satellites will be more and more needed to detect missiles since their launch, mainly through thermal infrared sensors, to enable fast and secure communication through the nodes of the missile defence architecture, to contribute to counter measures, including but not limited to electronic warfare. Here, the EU and its member states do benefit from cooperation praxis established through decades of investments through the European Space Agency (ESA), involving both the European Commission and national governments. Italy has played a significant role in this field since the early beginning. Building on that track record, Rome should exploit the synergy between space programmes and missile defence in a win-win logic. This would also enhance and complement the current NATO BMD, by adding a further layer and more resilience to an architecture which over-relies on the Turkey-based radar to counter Iranian missile threat.

Fifth, Italy should recognise that hypersonic weapons are both the most worrying threat and the next technological frontier. It is not by chance that China, Russia and the US are heavily investing in these systems, followed by France, India, Japan, the UK and Australia. In a nutshell, hypersonic weapons appear to be a true game-changer, therefore they deserve proper investments on research and technology trough cooperative European programmes. In particular, early warning, tracking systems and seekers are relatively more at hand for Italy than other components of missile defence.

Sixth, the continuity of Italian investments is a priority deeply influencing Italy's position. Now more than ever, certainty over budgetary allocation is needed on a mid-to-long-term horizon. Continuity is obviously not sufficient under a certain threshold of investments. Seventh, such investments should not only ensure the planned procurement or modernisation programmes, e.g. regarding the SAMP/T, but should also guarantee an adequate role in TWISTER and the EDF calls contributing to develop next generation systems. Otherwise, un-sufficient and fragmented funding allocation would result in un-effective and un-efficient results.

An eight key point regards public-private partnership in this sector – as in others. The worsening of the international security environment and the acceleration of technology innovation request a timely, systematic and continuous dialogue between the military and the industry, in order to address together threats assessment, requirements formulation, risks and opportunities for capability development. The industry would be better guided by sharing the military threat assessment, and the Armed Forces would benefit by an anticipation of relevant technological trends. This implies, for example, that military officials with operational experience should have more exchanges with industry's personnel in order to design and adjust together technological solutions. Moreover, partnerships should lead to a faster and more efficient technological innovation through subsequent tranches of state-of-the-art products, harvesting the benefits of open architectures in segments where Italian industries maintain design

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authority. Appropriate sharing of data gathered through military operations and activities would also enable the industry to better develop Command, Control, Communication and Computer (C4) systems. Certain limited technologies and components relevant for BMD have been already developed thanks to a variety of procurement programmes, ranging from the *Legge Navale* (Naval Law) to the Army's digitalisation, and these elements should be exploited in a synergic way through a stronger cooperation between the industry and the Armed Forces, as well as among the latters. At the same time, public-private partnership also entails a greater, deeper and more systematic collaboration between Leonardo, MBDA and Thales Alenia Space, also considering the industrial linkages among the three companies.

Ninth, when it comes to missile defence, the Italian military needs a leap forward in terms of jointness, which so far remains unsatisfactory. A fully fledged joint operational command for IAMD should be implemented building on the basis represented by the Poggio Renatico air operations command. Sensors and effectors operated by different services should be better integrated into a more centralised C2 structure, to better leverage the variety of current and upcoming assets – including space-based ones – and further streamline the response to ever faster threats. A more robust joint command should also address the upper layer of missile defence, obviously within the NATO IAMD architecture.

Las but not least, Italy should exploit the advantages of its geographic position in order to mitigate its very disadvantages. Geography puts Italy at the front line of missile attacks from North Africa and the Middle East, including from Iran and Libya. Rome should address this risk by proposing to host further, long-range radar systems to be integrated in NATO's IAMD – which would also mitigate the aforementioned vulnerability represented by the overreliance on the Turkey-based radar. Italy is already at the forefront in terms of intelligence and surveillance of NATO's southern neighbourhood, hosting components of the Allied Ground System (AGS) in Sigonella (Sicily), close to Niscemi, where a Mobile User Objective System (MUOS) installation is located, and this represent a solid basis on which to build in order to enhance the Italian role within NATO's IAMD.

These ten key points can only be effectively addressed by Italy through a more integrated, comprehensive and long-term approach to missile defence. Such an approach begins with the recognition of its relevance for national security, NATO's collective defence and EU cooperation, as well as for the industrial and technological capacities in Italy. Various aspects have to be blended together through a top-down coordination, vis inter-ministerial and joint levels and with regard to the public-private partnership. Missile defence is *per se* a highly integrated capability within NATO and in each major allied country – it can only be as such, otherwise it does not work. Metaphorically, Italy does need an equally integrated approach to missile defence in order to bring together the various bits and pieces into a coherent vision able to address the threats with Allies, to build on its relative strengths and to grasp the related cooperative opportunities in Europe. An integrated approach is traditionally difficult for Italians, but it is the only solution in this field.

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1. The importance of missile defence for Italy and Europe

by Vincenzo Camporini and Michele Nones[1]

The following Section will outline some observations concerning the complex geo-strategic context in which Italy operates, emphasising the role of missile defence within the national, European and transatlantic security framework.

The concept of missile defence was first introduced in the international strategic context at the beginning of the 1970s. That was the first time the idea of physically intercepting an object with sub-metric dimensions, travelling at a speed of 3 kilometres per second (km/s), became conceptually conceivable and technically feasible. Such possibility questioned the very principles of the Mutual Assured Destruction (MAD) doctrine, which, until then, prevented any prospect of a war. To maintain this balance, the United States and the then-Soviet Union (USSR) negotiated and signed the Anti-Ballistic Missile (ABM) Treaty, which prevented both parties from acquiring defence systems able to effectively protect them in the event in which one of them decided to launch a first strike against their opponent. At the time, the US was implementing the Strategic Defense Initiative, intended to reach a technological edge in missile defence. The USSR's attempt to catch up with the US in this sector, without having the adequate economic resources, was one of the causes for the dissolution of the Soviet Union and the end of the Cold War.

During that time in history, the logic behind missile defence was closely linked to the geo-strategic relationship between the two major world powers, which were engaged in an all-encompassing confrontation ranging from politics, to the economy, to the military. After the end of the bipolar system, and of the American unipolar moment which followed and which was supposed to bring about the so-called "end of history", the global conceptual framework experienced a rapid change and became increasingly unstable and complex.

Within this new context, certainties begun to fade, and, on the international arena, actors traditionally holding power and authority started to be questioned, due to the weakening of multilateral institutions (as well as the questioning of the very idea of multilateralism) and the proliferation of actors and hegemonic ambitions, at least at a regional level. On the international scene, the mutability of politics emerged, as did numerous challenges that governments need to face. Such challenges can take various forms, including unusual ones, thus still require preparedness by governments.

Through a quick analysis of the geo-strategic framework – including the super-national communities of which Italy is part, first and foremost the European Union – and of the regions where Italy holds its national interests, it is possible to clearly

[1] Vincenzo Camporini is Scientific Advisor at IAI. Michele Nones is Vice President of IAI.

seize its general instability. National aspirations of state actors add to or overlap with various interests of transnational organisations: some legitimate (such as those of prominent multinational corporations), some illegitimate, and some marked by religious or ideological features. It is important to understand how, when examined together, these interests appear rather unstable, and may fluctuate even within a short time frame: they might create casual and rapid convergences as well as divergences among the actors involved. That is why it is crucial to ensure a proper responsiveness which, to be feasible, must count on the availability of a vast array of tools, ranging from economic-financial measures, to diplomatic means, as well as technological-industrial and military instruments.

The last few centuries have been characterised by a steady technological edge of the West over the rest of the world. Such advantage consisted in an industrial, economic, financial, political and military supremacy which allowed Western societies to grow and develop, widening the share of the population living a more comfortable way of life. The period between the end of the 20th Century and the beginning of the 21st saw a great surge of globalisation, which, despite not being a new phenomenon, gained a whole new relevance. Globalisation radically changed relations between countries and societies, facilitating people's access to knowledge and boosting its dissemination.

Relationships changed deeply also in the military technology field and, more generally, with respect to those technologies used directly or indirectly in the development of weapon systems, impacting the very geo-political structure of the Western world. The development and peculiarities of the European integration process represent a fitting example of such adjustments: despite the positive effects brought to our societies by the market widening process and the elimination of barriers within the Union, the benefits of these processes excluded the military sector in which, to this day, there continues to be a sort of protectionism. Therefore, leaving aside world powers, the dimensions of national markets in the military sector have long been insufficient to guarantee the survival, in economic terms, of companies with high capitalisation rates, forcing them to look for export opportunities to sustain themselves. In the meantime, the international market experienced a deep transformation. Up until the end of the 20th Century, if a product seemed cutting edge to the customer, and perhaps came with ensured logistical support, it was enough to make the sale. The country making the purchase would then become almost "dependent" upon the supplier State. Besides securing an economic advantage, the latter would obtain a relevant political gain it could benefit from in the medium term. Together, economic development and globalisation made "clients" long for a higher degree of independence in military technology, therefore making them more interested in technological transfers and support in training and logistics rather than industrial compensations – as generous as they might be. Within the international defence market, military exports turned increasingly from supplies done in the framework of a buyer-supplier exchange, into "collaboration relationships", so much so that they are

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often part of Government-to-Government (G2G) agreements.[2] Lacking a proper integrated European defence market, European defence industries in particular find themselves in the midst of a fierce intra-European competition, pressuring them to offer collaborations or joint participations to programmes, on-site assembling, and development of local industrial capabilities. The mutability and unpredictability of the overall political and strategic context, coupled with the instability of numerous authoritarian regimes, might create not just dangerous competitors for future markers, but also potential opponents.

Furthermore, after a prolonged absence of non-state actors on the international scene, which, in the Western world, was due to the consolidation of the concept of nation-state and its exclusive political relationship with European populations, there is now a come-back of non-state actors able to influence events in the Old Continent. Today, countless organisations of different kinds have found their place beside states and multilateral institutions, and they do not seem to be subject to any specific authority. They include Non-Governmental Organisations (NGOs), transnational financial and entrepreneurial companies, criminal organisations, and even indistinct (though skilled) groups founded on ethnical, tribal and religious faiths, which sometimes resort to violent acts of terror.

Against this backdrop, the present study will address a core issue: what is the strategic rationale of Italian missile defence in the national, European and international context and in relation with the security organisations of which it is part, such as the North Atlantic Treaty Organization (NATO)? Do decision-makers and public opinion understand such rationale?

Missile technologies have now become widely available and confidentiality measures do not represent strict limits anymore, neither for States nor for non-state well-organised entities. Therefore, it should not be assumed that missile systems, even if rudimental, are out of the reach of either States – no matter how small or technically limited – or non-state actors that aspire to play a role in the international arena. Due to the instability near their borders, Italy and its Western partners had to resort to military power to ease rising tensions more than once in the recent past. That was, for instance, the case of inter-ethnic conflicts like the one in the Western Balkans; inter-confessional strifes as the one that erupted and continues to agitate the Middle East; or tensions caused by conflicting economic and strategic interests, as happened in Libya. Neither Italy nor the EU, NATO or other coalitions of allies can afford to overlook similar situations, as they have both direct and indirect effects on the Italian and European society, ranging from consequences on the energy sector to migration flows. In order to actively shape the debate around these issues, rather than just having to adapt to it, it is important to take a stand in the definition of geo-strategic dynamics. This obviously entails

[2] For more on this issue, see: Alessandro Marrone and Ester Sabatino, "Defence G2G Agreements: National Strategies Supporting Export and Cooperation", in Documenti IAI, No. 20|17 (September 2020), https://www.iai.it/en/node/12070.

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a set of risks, pressures or even threats on behalf of those actors with opposing views and interests, at times even manifested via their missile systems. A similar instance took place in 1986, when the Libyan regime led by Gheddafi launched SS-1 Scud missiles against Sicily, Italy, and more recently when, during the allied air operations of 1999, representatives of Milosevic’s Serbian regime threatened to launch Scud missiles over Italian cities.

The scenarios to be taken into consideration range from conventional military confrontations, which cannot be completely ruled out and which would not necessarily consist in an unlikely Russian aggression against NATO members, to intimidations and retaliations moved by autocrats who feel cornered by the international community, to demonstrative actions by extreme Islamist terrorist organisations. What is more, missile defence constitutes an important asset for the protection of Italian Armed Forces deployed in missions abroad, as well as part of the Italian contribution to the collective defence of NATO Allies.

It is worth noting that even the threat of a possible missile attack – which might well carry nuclear warheads or other weapons of mass destruction – might exert such a pressure to overshadow a country’s national interests. In this sense, missile defence systems became (and still represent) a deterrent for countries that acquire them. Deterrence is a key concept of American politics which, *mutatis mutandis*, also applies to European members of the Alliance (including Italy), which greatly benefit from participating in NATO’s Integrated Air and Missile Defence (IAMD). Without such Allied defensive architecture, which is based on the Aegis land and sea bases for its missile defence capability, the European territory would be much more exposed to potential missile threats posed by regional actors and world powers whose relationship with the Western world has dramatically worsened within the last decade. Moreover, while in the past only great powers could afford their own national arsenal of missile systems, today such arsenals are within the reach of a plethora of state and non-state actors whose political power is not commensurate to the danger posed by their missiles. The fact that, at least for the time being, there are strict regimes controlling nuclear weapons, cannot be used as an argument to underplay the risk presented by missile systems. Politically speaking, the potential disastrous consequences of a missile attack conducted with conventional warheads justify any attempt necessary to prevent them since, if a missile hit a large urban centre, the number of casualties it would cause would be unbearable for a Western democracy. In addition, it should be noted how, even if a national missile defence system managed to intercept an incoming missile attack, the country would still have to tackle the problem of the missile’s demolition. Such operation would inevitably cause falling debris which, besides being an environmental damage, might become a danger to society if the demolition were to take place over the national ground. What is more, one cannot rule out the possibility that a missile might be carrying unconventional weapons such as chemical or radiological (besides nuclear) arms, which would have devastating consequences on the environment, namely a widespread contamination. Lastly, a vast array of offensive systems should be taken into consideration, ranging from ballistic missiles – from the most sophisticated ones to more rudimental ones and missiles with limited

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precision strike which, however, pose an unacceptable threat of blackmail – to drones, now available in a largely uncontrolled manner, and which sometimes present tactically significant features. In the meantime, new missile systems that are especially difficult to intercept are about to become operational. An example is offered by hypersonic gliders which, differently from less sophisticated ballistic missiles, for example, do have a distinctive military relevance. For now, only great powers such as China, Russia and the US possess such systems, but it might be wise to invest national technological resources for the development of efficient defence systems, considering also that other countries like Australia, France, Japan, India and the United Kingdom (UK) have their own ongoing programmes.

Therefore, Italy must choose between accepting the risk of being blackmailed by those who are interested in influencing the national (and European) political agenda, or acquiring the appropriate means that would make any blackmail of that sort ineffective. It is time to make a realistic assessment of the available technological and industrial capabilities, knowing that no European country currently possesses neither the knowledge nor the resources needed to develop and deploy defence systems capable to effectively counter such a variety of missile threats. Perhaps, a common initiative in this field among several European member states, developed in the EU framework and in synergy with NATO, might resume the process towards a more ambitious and long-awaited European defence integration. That is precisely the direction in which projects of the EU's Permanent Structure Cooperation (PeSCo) should be headed. Suitable examples are offered by the Timely Warning and Interception with Space-based Theater Surveillance (TWISTER) project, which will contribute to NATO's missile defence system, and NATO's multinational High Visibility Projects (HVPs) announced in October, aimed at developing defence systems able to counter short and medium-range missiles. Being part of both initiatives, Italy should take advantage of this great opportunity to build its own missile defence capabilities, as well as the related technical and industrial competences and know how.

Missile defence within the NATO framework deserves a separate discussion, not just because of the US' involvement. The Alliance holds specific competences and responsibilities for its members' IAMD – which basically includes the entire European continent – and missile defence is part of it. That is why national operational units, including guided missile interceptors and surface-to-air missile units, are always deployed by member states, therefore report directly and without mediators to the orders mandated from the respective NATO operational commands. Within the transatlantic framework, pressures by the American defence industrial sector might heavily influence solutions to technical-operational problems, as the US industry already developed highly effective missile defence systems. It is worth noting that the US approach was the main reason behind the sub-optimal results of the transatlantic collaboration attempted in this sector through the Medium Extended Air Defense System (MEADS) programme. This record should serve as an additional incentive to begin an intra-European collaboration, which would need to be adequately supported by the European institutions. A similar collaboration would not entail an anti-American posture, quite the opposite: it should be

developed within the framework of the transatlantic Alliance, which will only prove efficient, concerted and sustainable if marked by a fair balance between the two sides of the Atlantic, from both an operational and a technological standpoint.

Against this backdrop, it is paramount to make an analysis of missile capabilities available outside NATO's perimeter – including capabilities of countries which currently are or might potentially be considered hostile – of the technological overview of the Euro-Atlantic area, and of the experience of NATO's most missile-capable members (namely France, Germany, Poland, Turkey, the UK and the US). With regards to Italy, it should aim to gain a better understanding of the international scene, increase its awareness over the numerous aspects of missile defence, and develop its own national perspective to be presented in a constructive and proactive manner within the European and transatlantic context.

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2. Technological innovation and Euro-Atlantic industrial landscape

by Douglas Barrie[3]

For 30 years, the ballistic missile threat to Europe was bounded by the 1987 Intermediate-Range Nuclear Forces (INF) Treaty.[4] Its collapse in August 2019 once again raises the possibility that Europe is faced with a class of delivery systems that the treaty between Washington and Moscow had eliminated for just over three decades.

The cause of the US withdrawal from the INF was not a ballistic missile, but rather Russia's 9M729 (SSC-8 Screwdriver) ground-launched cruise missile, that Washington and later its NATO Allies alleged was a material breach of the Treaty.[5] The 9M729, highly likely based on the 3M14 (SS-N-30A Sagaris) naval land attack cruise missile, has a claimed range of up to 2,500 kilometres (km). The INF prohibited 500-5,500 km range ground-launched missiles.[6] Nonetheless, the breakdown of the Treaty brings with it the renewed threat of "theatre"-class ballistic missiles deployed within range of Europe, not in the handfuls of numbers of any once envisaged Iranian capability, but in the large numbers Moscow could potentially field.

Any high-level consideration of the technical aspects of Ballistic Missile Defence (BMD) needs to first consider the nature of the possible threat and the level of ambition regarding what is to be defended. BMD additionally needs to be considered in the context of wider Air and Missile Defence (AMD) capabilities. There is no value in pursuing BMD if this is not complemented by the ability to adequately counter air-breathing threats. Defeating a ballistic missile only to be struck by a ground- or air-launched cruise missile or other air-to-surface munitions would be simply a waste of resource. Whatever else BMD is, it is certainly expensive. The only greater cost could turn out to be not having any.

The threat spectrum that could be addressed now spans from non-state actors with access to at least mature if not obsolescent ballistic missiles, to advanced ballistic missile systems and emerging technologies such as boost-glide vehicles, being pursued by Russia. For the sake of brevity, this Section assumes that there is no ambition to pursue a full-blown BMD architecture aiming to defeat an attack of the scale that could be expected in an unconstrained nuclear war involving Russia and NATO. Even were the technology to be mature enough to attempt this – and this is

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[4] US Department of Defense (DoD) website: *Intermediate-Range Nuclear Forces Treaty - Strategic Deterrence and Capabilities*, https://www.acq.osd.mil/asda/iipm/sdc/tc/inf/INFtoc.htm.

[5] US State Department, *U.S. Withdrawal from the INF Treaty on August 2, 2019*, 2 August 2019, https://2017-2021.state.gov/u-s-withdrawal-from-the-inf-treaty-on-august-2-2019.

[6] US DoD website: *Intermediate-Range Nuclear Forces Treaty*, cit.

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not yet and may never be the case – the disincentives in terms of cost and, perhaps counter-intuitively, the risks to what remains of strategic stability may militate against this. Instead, what could be achievable would be the ability to better provide missile defence towards short-or-close-range (less than 1,000 km), medium (up to 3000 km) and intermediate-range ballistic missiles (up to 5,500 km),[7] as well as air-launched ballistic missiles and hypersonic glide vehicles and hypersonic cruise missiles.

The challenge of engaging targets capable of hypersonic flight is not new. Hypersonic flight is generally held to be at speeds in excess of Mach 5, while supersonic speeds cover the envelope between Mach 1 and Mach 5. Most of a ballistic missile's flight will be in the hypersonic speed regime. Where the emerging new class of systems capable of achieving hypersonic flight differs is that most, if not all, of the flight is within the atmosphere. Furthermore, even a glide vehicle will offer far greater cross-range maneuverability than a ballistic missile bus or re-entry body.

Weapon system developers have been interested in air vehicle flight at speeds greater than Mach 5 for decades. In the US, 1950s very-high speed flight research culminated in the X-15 programme. The air vehicle was flown for the first time in 1959. The rocket-powered aircraft was eventually to be flown at speeds of up to Mach 6.7 (6,800 kilometres per hour - kmph) during the 1960s. While an extraordinary achievement, the programme also underscored the technical challenges of very high-speed flight and the gulf between an experimental programme and the development of a weapon system capable of being flown at such speeds.

Russia's Strategic Rocket Forces now have a small number of the RS-18 Avangard hypersonic boost-glide systems (RS-SS-19 Stiletto Mod 4) in service with the 13th Missile Division at Dombarovsky, in the South-West of the country. Moscow has been forced to introduce its hypersonic glide body on a 1970s designed intercontinental ballistic missile because development of the intended launch vehicle, the Sarmat (RS-SS-X-29), is lagging behind schedule.

The Avangard system builds on work carried out by NPO Mashinostroyenia the 1980s on the Albatros project. This programme was one of a number of responses to the US Strategic Defence Initiative, and was intended to develop a Hypersonic Glide Vehicle (HGV) to counter Washington's missile defence efforts. The project fell into abeyance in the early 1990s, following the collapse of the USSR and the resulting precipitous decline in defence spending. The US withdrawal from the 1972 ABM Treaty in 2002 and its increased interest in missile defence may have prompted Moscow to revive its HGV work.

[7] US National Air and Space Intelligence Center (NASIC), *Ballistic and Cruise Missile Threat 2017*, June 2017, p. 8, https://www.hsdl.org/?abstract&did=801949.

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Moscow is also continuing to test the 3M22 Tsirkon. This appears to be a very high-speed cruise missile initially intended for the anti-ship role, but which may also offer the basis for a land-attack weapon. The missile has a cruise speed in excess of Mach 5.

The scale of ambition for missile defence could be to protect civilian populations from a "rogue" attack, though the likelihood of such a strike is debatable, and to be able to offer coverage of critical national infrastructure, including military sites, along with deployed units.

The Yemeni Civil War is illustrative of the way in which the use of ballistic missiles is becoming normalised, in this case in part to offset the Saud-led alliance's dominance in the air domain. Some of Burkan variants of the Scud used by Houti militia Ansar Allah have ranges of 900 km plus,[8] with Iran assessed widely to have been the source of the missiles.[9] Notionally, from the Northern coast of Libya, such a system would put the bottom half of Italy within range. And in January 2020, Tehran launched a missile attack against two bases in Iraq that were being used by the US and allied forces. Noteworthy in both is the number of missiles: in the latter case, Iran launched 12 plus against two targets in a single strike,[10] while Ansar Allah has used substantially more over several years. Also notable, however, is often the comparatively limited damage inflicted by the weapons. Passive defence, combined with the ability to accurately predict the impact point of at least some of the ballistic threat systems, can contribute to managing the defensive challenge.[11]

The technology aspects of BMD also cannot be unpicked completely from political concerns and constraints. The most effective approach to provide even limited BMD for Europe, be this NATO, the EU or both, would be through a fully integrated architecture. In turn, this would be part of an overarching AMD infrastructure. Such an architecture, however, would require the relinquishing of sovereignty at a level that would be problematic. Sharing, rather than full integration, would appear more achievable in the near-to-medium-term.

2.1 Technology requirements

There is nothing fundamentally different in intercepting a ballistic missile than other kinds of air (or space) target. The sensors, intercept vehicles, and kill mechanism are however required to accommodate target velocities and closing

[8] See for example: Jeremy Binnie, "Iran Supplies Ballistic Missiles to Ansar Allah", in *Jane's Defence Weekly*, 22 December 2017.

[9] See Annex 13, "Components of Extended-Range Short-Range Ballistic Missiles", in UN Security Council (UNSC), *Final report of the Panel of Experts on Yemen* (S/2019/83), 25 January 2019, p. 92-93, https://undocs.org/S/2019/83.

[10] US DoD, *DOD Statement on Iranian Ballistic Missile Attacks in Iraq*, 7 January 2020, https://www.defense.gov/Newsroom/Releases/Release/Article/2052103.

[11] See for example: Michael Elleman and Toby Dodge, *Missile-Defence Cooperation in the Gulf*, London/New York, Routledge, 2016, p. 56.

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or crossing speeds way beyond most other kinds of engagement. In some cases, this may require a level of automation or machine-based decision making that again would militate against an integrated multi-national architecture. Europe's defence industrial base has already developed, and in some cases deployed, the radar and infra-red sensor technologies and the missile interceptors to support a more capable BMD.

BMD requires the detection and destruction of the ballistic threat at some point prior to impact, either pre- or post-launch.[12] And in intercept terms, the least demanding of these is when the missile has zero velocity, that is prior to launch, when it remains on the ground. Irrespective of the method of engagement, however, a range of sensors will be required to find, identify and track the target. These ideally will include a space-based launch detection capacity combined with space-based, ground-based and ship-borne radars, also for early warning and for in-flight tracking and target discrimination. A digital battle management backbone is also needed. Most elements of the architecture required to support post-launch engagements are also applicable to a pre-launch approach.

Likely, the most effective missile defence is one adopting a layered approach.[13] This would provide the ability to engage the missile at all stages from pre-launch, through boost phase, midcourse and then terminal engagement. Each of these, however, also brings with it a set of technology challenges, and differing levels of technical maturity.

In terms of pre-launch engagement, several European states have already fielded some of the requisite capabilities. These include the capacity for precision strike from the air at stand-off ranges. The capability gaps here are more to do with air- and space-based Intelligence, Surveillance and Reconnaissance (ISR) and the capacity to rapidly exploit data to shorten the engagement cycle as much as possible. Near-real time targeting updates require persistent ISR coverage – air-, satellite-based or both – to provide as much coverage of the geographical area of interest as a possible. The Scud-hunting challenges faced by the US coalition in the 1991 Gulf War,[14] and more recently of the Saudi-led coalition involved in the Yemeni Civil War attest, however, to the lasting difficulty in the timely location of mobile missile launchers.

Immediately post-launch there are also attractions to the boost phase intercept. The missile's motor is still burning providing a large infra-red signature for detection and tracking, while a successful intercept will result in the debris falling most likely on the launcher's territory, rather than that of the defender's or of a third country. However, the problems of boost-phase intercept approach are

[12] Ibid., Ch. 4.

[13] Ibid., p. 89.

[14] Herbert C. Kemp, "Left of Launch: Countering Theater Ballistic Missiles", in *Atlantic Council Issue Briefs*, July 2017, p. 2, https://www.atlanticcouncil.org/?p=105514.

similar to those of a pre-launch engagement, in terms of persistence and coverage, and are compounded by the demands of engaging a rapidly accelerating target and of intercept geometries that may place further demands of the performance of a notional interceptor. Moreover, the intercept would likely operate in hostile air space, adding further challenges. Unmanned Aerial Systems (UASs) offer one route to meeting the need for persistence. However, against all but a threat with no air defence capabilities, such platforms risk being unacceptably vulnerable.

To date, midcourse and terminal engagements have been the two favoured approaches to BMD that, when used in concert, arguably provide the most effective means of countering a ballistic missile attack.[15] Midcourse engagements are exo-atmospheric and occur at ranges and against a target set that place demands on sensor detection and discrimination, as well as on interceptor kinematic and end-game performance. The warhead section of ballistic missiles with ranges greater than 500 km will most often separate following the boost phase providing a far smaller radar cross-section and, in the case of a capable opponent, may also be accompanied by a range of decoys and counter-measures.

Terminal engagement, by comparison, places differing demands on the interceptor missile in terms of kinematic performance. While it does not have to fly as far, high acceleration is required given the comparatively narrow amount of time before impact. Warhead re-entry is generally between 30 and 50 seconds. And while a midcourse approach may allow for a shoot-look-shoot approach using single interceptors, in the terminal phase achieving the required probability of a kill may well require the simultaneous launch of two interceptors, with the requisite cost penalty. This price, however, will likely be less than that of a failed intercept. The demands on defence are even greater if cruise missiles, from subsonics to hypersonics, are included in the threat picture. Low- or very low-observable cruise missiles using terrain-following flight paths, or high-altitude high-speed cruise missiles and glide bodies capable of in-atmosphere maneuvers, further complicate the defender's task.

2.2 Europe and the US

The US has unsurprisingly taken the lead in BMD within NATO, including the two Aegis Ashore sites and the basing of four Aegis-class ships in Spain. Patriot and Surface-to-Air Missile Platform/Terrain (SAMP/T) systems provide additional capabilities. The Aster 30 Block 1 NT upgrade will allow the SAMP/T to be used against longer-range ballistic missiles. Now in development, the Block 1 NT provides for engagement of ballistic missiles with more than double the range of the Aster 30. The latter could be used to engage ballistic missiles with ranges up to 600 km – when introduced into service, the Aster Block 1 NT will more than double the target-range envelope.

[15] See for example: Michael Elleman and Toby Dodge, *Missile-Defence Cooperation in the Gulf*, cit., p. 89.

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If and how Europe will choose to pursue a greater BMD capability will require decisions as to the level of transatlantic cooperation or acquisition with regards to missile defence technologies.

Technology cooperation has not always been easy. In 1996, the MEADS brought together the US, Germany and Italy to develop an air and tactical BMD system. Germany is the only participating country that decided in principal to go ahead with buying the system in 2015 but, as of August 2020, a production contract had yet to be signed.[16] The primary interceptor for the *Taktisches Luftverteidigungssystem* (TLVS) is the US Patriot Advanced Capability-3 Missile Segment Enhancement (PAC-3 MSE). Poland, Sweden and Romania will also field the PAC-3 MSE missile as part of their respective Patriot Surface-to-Air Missile (SAM) system orders.

MBDA is also involved in a next-generation surface-to-air system, the requirement for which is being driven by emerging missile threats. Under the EU's PeSCo initiative, five European countries have signed up to the TWISTER project.[17] France is the coordinating nation, with MBDA France likely the industry lead, while Finland, Italy, Netherlands, Germany, and Spain are also project members.[18] TWISTER is intended to use an endo-atmospheric interceptor to engage intermediate- and medium-range ballistic missiles, as well as hypersonic glides and powered systems. The intent is to have the system ready for service entry by 2030.[19] While MBDA has a UK arm, and London has a long-standing, if unfunded, interest in missile defence, leaving the EU poses a challenge with regards to participating in PeSCo funded programmes.[20] How TWISTER would fit with TLVS in Germany is also an open question, but the TWISTER interceptor could potentially also be integrated into the overall TLVS architecture.

[16] Sebastian Sprenger, "German Government Asks Lockheed Martin, MBDA to Rebid on Missile Defense System", in *Defense News*, 6 May 2020, https://www.defensenews.com/global/europe/2020/05/06/german-government-asks-lockheed-mbda-to-re-bid-on-missile-defense-system.

[17] PeSCo website: *Timely Warning and Interception with Space-Based Theater Surveillance (TWISTER)*, https://pesco.europa.eu/project/timely-warning-and-interception-with-space-based-theater-surveillance-twister.

[18] Ibid.

[19] MBDA, *MBDA Ready to Meet the Challenge of Europe's Missile Defence*, 13 November 2019, https://www.mbda-systems.com/?p=17753.

[20] Lucie Béraud-Sudreau, "UK Access to European Defence Research Funds: Another Brexit Uncertainty?", in *Military Balance Blog*, 31 January 2019, https://www.iiss.org/blogs/military-balance/2019/01/uk-future-eu-defence-funding.

3. Missile Capabilities Outside NATO

by Michael Elleman[21]

Ballistic missiles are valued because they can deliver a relatively large warhead across borders to great distances in a short time. They can be launched with little or no warning, fly to their assigned targets autonomously, and penetrate all but the most sophisticated defensive systems. These attributes make ballistic missiles an attractive option for delivering nuclear weapons. It is no coincidence that each of the world's nine nuclear-armed nations – the US, the UK, Russia, France, China, India, Israel, Pakistan, and North Korea – field advanced ballistic missiles to deliver them.

Non-nuclear weapons states also covet ballistic missiles for similar reasons. For some, most notably Iran, ballistic missiles provide an extra-territorial strike option and an alternative to the advanced aircraft, which Tehran has not been able to afford or obtain because of international sanctions. North Korea viewed ballistic missiles similarly, before it became a nuclear-weapons state.

This Section summarises the ballistic and cruise missiles capabilities of seven non-NATO countries, including Russia and China. Where applicable, missile defence capabilities are briefly described.

3.1 China

Following its first nuclear test in 1964, China proclaimed that it would not be the first to employ nuclear weapons in conflicts or crises. Beijing's no-first-use pledge has been the guiding principle underlying China's "minimum deterrence" nuclear strategy. Maintaining an "assured retaliation" posture is founded on the belief that China can survive a pre-emptive attack and retaliate proportionately. The US pursuit of long-range strike capabilities using dual-capable weapons reinforced with national missile defences may alter Beijing's strategic calculus, as evidenced by recent Chinese statements and investments. China's decision to arm its new road and rail-mobile Intercontinental Ballistic Missile (ICBM) DF-41 and possibly the DF-31AG ICBMs with Multiple Independently targetable Re-entry Vehicles (MIRVs), as well as the recent introduction of the DF-17 missile equipped with conventionally armed HGVs, may mark the first steps of a re-configured force posture going beyond China's long-standing minimum-deterrence nuclear doctrine.[22]

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[22] Gregory Kulacki, "China's Military Calls for Putting Its Nuclear Forces on Alert", in *Union of Concerned Scientists Reports*, January 2016, https://www.ucsusa.org/resources/chinas-military-calls-putting-its-nuclear-forces-alert; Minnie Chan and Kristin Huang, "Is China About to Abandon Its 'No First Use' Nuclear Weapons Policy?", in *South China Morning Post*, 7 February 2019, https://www.scmp.com/news/china/military/article/2184577/could-china-abandon-its-no-first-use-

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China's nuclear capabilities and the size of its arsenal are shrouded in secrecy, making them difficult to summarise in a coherent and consistent manner. Experts who closely study Beijing's nuclear programme believe that China possesses about 290 nuclear warheads,[23] although a 2020 study projects an arsenal of 380 weapons.[24] If the 290 value is accepted, the People's Liberation Army Rocket Forces (PLARF) deploys approximately 186 nuclear warheads on its roughly 90[25]-to-120[26] land-based, nuclear-armed ballistic missiles, organised as launch brigades subordinate to six Army-level missile bases.[27] The Chinese Navy possesses an additional 48 warheads carried by 48 JL-2 Submarine-Launched Ballistic Missiles (SLBMs) deployed on four operational JIN-class nuclear-powered submarines, known as Ballistic Missile Submarines (SSBNs).[28] A small number of nuclear weapons are thought to be assigned to a mix of H-6 bombers and a few fighter-bomber aircrafts.

Beijing continues to field its relatively small nuclear arsenal on land-based, liquid-fuel ballistic missiles, the legacy of *Dongfeng* (East Wind) DF-4 and DF-5 ICBMs. Both are deployed in either underground silos or caves, where the missile can be wheeled out, prepared for launch (and fuelled) on a nearby, pre-surveyed launch pad. The 5,500 km range DF-4 (CSS-3) ICBM entered military service in 1980. Only one brigade remains deployed, and it operates an estimated five DF-4s, each fitted with a single, 3.3 megaton (Mt) thermonuclear warhead.

The DF-5A (CSS-4 Mod 2) ICBM, initially deployed in 1981, is armed with one, 4-to-5 Mt warhead, while the DF-5B (CSS-4 Mod 3) carries three 200-to-300 kiloton (kt) warheads. China operates three DF-5 brigades comprised of an estimated 10 DF-5As and 10 DF-5B ICBMs.[29]

nuclear-weapons-policy.

[23] Hans M. Kristensen and Robert S. Norris, "Chinese Nuclear Forces, 2018", in *Bulletin of the Atomic Scientists*, Vol. 74, No. 4 (25 June 2018), p. 289-295, https://doi.org/10.1080/00963402.2018.1486620; Hans M. Kristensen and Matt Korda, "The Pentagon's 2019 China Report", in *FAS Reports*, 6 May 2019, https://fas.org/?p=36604.

[24] Stockholm International Peace Research Institute (SIPRI), *Nuclear Weapon Modernization Continues But the Outlook for Arms Control Is Bleak: New SIPRI Yearbook Out Now*, 15 June 2020, https://www.sipri.org/node/5146.

[25] US DoD, *Military and Security Developments Involving the People's Republic of China 2019. Annual Report to Congress*, 2 May 2019, https://media.defense.gov/2019/May/02/2002127082/-1/-1/1/2019_CHINA_MILITARY_POWER_REPORT.pdf.

[26] Hans M. Kristensen and Robert S. Norris, "Chinese Nuclear Forces, 2018", cit., p. 289-290.

[27] International Institute for Strategic Studies (IISS), *The Military Balance 2020*, February 2020, p. 259.

[28] Hans M. Kristensen and Robert S. Norris, "Chinese Nuclear Forces, 2018", cit. The "SS" denotes "submarine" or "submersible", the "B" denotes "ballistic missile," and the "N" denotes "nuclear powered".

[29] Missile and brigade numbers are estimated from two primary sources: IISS, The Military Balance 2020, and Hans M. Kristensen and Robert S. Norris, "Chinese Nuclear Forces, 2018", cit. Occasionally, the estimated numbers do not match, in which case the stated value is from *The Military Balance 2020*, as it is a more recent publication.

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In modernising its nuclear force structure, China's older, liquid-fuel ICBMs are being replaced with more survivable, accurate, and operationally flexible force of road-mobile, solid-fuel ICBMs. In 2006, the PLARF began deploying three-stage DF-31s (CSS-10 Mod 1) into a single brigade, with each of the eight road-mobile ICBMs armed with a 200-to-300 kt nuclear warhead.[30] An upgraded version – the DF-31A (CSS-10 Mod 2) – entered service in 2007, with roughly 24 DF-31A ICBMs fielded in two brigades. The DF-31AG, which became operational in 2017, is deployed on a different Transporter-Erector-Launcher (TEL) than other DF-31 variants. Rumours suggest that the DF-31AG may be a MIRV, but this and other possible upgrades have not been publicly confirmed. An estimated 18 DF-31AG ICBMs are under the control of two brigades.

The DF-41 (CSS-20) is China's newest and most capable ICBM. It carries either a single 1 Mt warhead, or 10 MIRV warheads with a nuclear yield of 90-to-120 kt.[31] Roughly 18 DF-41 missiles are thought to be entering service within two brigades.

The solid-fuel DF-26 is a dual capable road-mobile Intermediate-Range Ballistic Missile (IRBM) with an estimated range of 4,000 km. Roughly 76 missiles are operated within four DF-26 brigades. In addition, there are six brigades equipped with a total of about 80 DF-21 A/E (CSS-5 Mod 2/6) nuclear armed Medium-Range Ballistic Missiles (MRBMs). Other MRBM variants are conventionally-armed. Three Short-Range Ballistic Missile (SRBM) brigades are deployed in the vicinity of the Taiwan straits consisting of 108 DF-11A (CSS-7 Mod 2) missiles and about 81 DF-15B (CSS-6 Mod 3) missiles. The PLARF operates two brigades equipped with a total of about 54 CJ-10/CJ-10A and 16 CJ-100 conventionally armed, ground attack cruise missiles.

China does not operate strategic missile defences capable of intercepting ICBMs or IRBMs. The S-300PMU2 (SA-20 Gargoyle) and the S-400 (SA-21 Growler) air-defence systems imported from Russia have some capacity against SRBMs and MRBMs.

3.2 India

Since 1998, the Indian government outlined its nuclear no-first-use policy and a "credible minimum nuclear deterrence" force posture.[32] While India's no-first-use policy remains intact, its premise has been repeatedly questioned by government officials and Indian scholars alike.

[30] Hans M. Kristensen and Robert S. Norris, "Chinese Nuclear Forces, 2018", cit.

[31] Bill Gertz, "China Flight Tests New Multiple-Warhead Missile", in *The Washington Free Beacon*, 19 April 2016, https://freebeacon.com/?p=593854.

[32] "India's Draft Nuclear Doctrine", in *Arms Control Today*, Vol. 29, No. 5 (July/August 1999), p. 33-34, https://www.armscontrol.org/node/514.

Like India's nuclear programme prior to 1998, its civilian space programme and efforts to develop satellite-launchers established the foundation upon which the Defence Research and Development Organisation (DRDO) designed and developed a series of Prithvi and Agni ballistic missiles. It is notable that DRDO still relies on the Indian Space Research Organisation (ISRO) to produce the large, solid-fuel motors that propel its Agni-family of missiles.

Over the past three decades, the Prithvi has been upgraded several times, with one version of the missile serving as an interceptor for an indigenously developed missile defence system, and another as the ship-based Dhanush SRBM. An estimated 30 Prithvi II (SS-250) missiles are nuclear-armed to provide India with an initial, and continuing, capacity to deter Pakistan.

In the mid-1990s, India began development work on the 2,000 km range, two-stage, solid-fuel Agni-II and the single-stage Agni-I, which has a range of about 700 km. India fields an estimated 12 nuclear-armed, road- and rail-mobile Agni-I missiles and an equivalent number of Agni-IIs, which serve to deter Pakistan.

India has or is developing three additional Agni missiles to deter China and solidify its status as a regional power. The 3,500 km range Agni-III was initially deployed in 2014, but in small, unknown numbers.[33] The Agni-IV IRBM (occasionally referred to as the Agni-II+) remains under development, as does the Agni-V ICBM. The Agni-V will be capable of targeting sites anywhere in China.[34] It is unclear when the Agni-IV and -V will reach operational status, as flight trials for both continue.

Delhi has also developed several sea-based missiles. The nuclear-armed Dhanush (SS-350) is a shipped-based, liquid-fuel missile derived from the Army's Prithvi SRBM that is deployed on two surfaces ships.

India's first nuclear-powered submarine, INS Arihant, is a technology demonstrator that has undergone sea acceptance trials. Its four launch tubes will be armed with solid-fuel ballistic missiles currently under development, the 700 km range Sagarika (K-15) and the 3,500 km range Shaurya (K-4).[35] A second SSBN, the INS Arighat, was launched in November 2017, with two more submarines planned.[36]

India has jointly developed a supersonic, anti-ship cruise missile with Russia. Known as BrahMos, the cruise missile has a range of 300-500 km, travels at speeds up to Mach 3, and can be launched from land, sea, and air. It is armed with a

[33] Hans M. Kristensen and Matt Korda "Indian Nuclear Forces, 2018", in *Bulletin of the Atomic Scientists*, Vol. 74, No. 6, p. 361-366, https://doi.org/10.1080/00963402.2018.1533162.

[34] Ibid.

[35] Naval Technology website: *Arihant Class Submarine*, https://www.naval-technology.com/projects/arihant-class.

[36] Rahul Bedi, "India Quietly Launches Second SSBN", in *Jane's Defence Weekly*, 11 December 2017.

conventional warhead.[37] India is also developing the Nirbhay, a ground-launched, sub-sonic cruise missile having a range of 700-1,000 km. Unlike BrahMos, the Nirbhay is rumoured to be dual-capable.[38]

3.3 Iran

It is difficult to overstate the importance of the 1980-88 Iran-Iraq War in shaping Iran's national strategy and its approach to warfare. The conflict cemented Tehran's doctrinal focus around three axes: proxy warfare and the use of its vast influence network, asymmetric warfare, and ballistic missiles. All of Iran's ballistic missiles are equipped with conventional warheads.

During its war with Iraq, Iran's cities and industrial infrastructures were repeatedly attacked with long-range artillery, ballistic missiles, and fighter-bomber aircraft. Tehran was unable to respond in kind until it acquired Soviet-made, liquid-fuel Scud-B (R-17E) missiles. The horrific memories of Iraq's devastating missile strikes on its urban centres, and the psychological boost Iranians gained from retaliatory attacks using Scud-Bs, convinced the rulers in Tehran of the strategic importance of maintaining a robust ballistic missile force structure.

In parallel with its efforts to import and modify liquid-fuel missiles, Iran established the infrastructure and developed the technical wherewithal to produce solid-fuel rockets and missiles indigenously, thereby freeing itself from the vagaries of foreign suppliers. This led to the manufacture and testing of a large, two-stage, solid-fuel Sajjil MRBM, beginning in 2008. However, the 2,000 km range Sajjil has not been test launched or fired during military exercises since 2011, suggesting that unknown technical challenges precluded its deployment to the military.

The military utility of the missiles Iran possessed before roughly 2010 was severely limited by their poor accuracy. Against large-area targets, such as an airfield or a seaport, Iran could conduct harassment attacks aimed at disrupting operations or causing damage, but such attacks could not be used to halt its adversary's critical military activities. Given their limited military utility, Tehran viewed its missiles as a tool to deter attacks by regional rivals, by threatening to punish an adversary's population and civilian infrastructure, as it did when attacking Baghdad and other cities during its war with Iraq. Recognising that threats to retaliate against armed aggression by its regional adversaries and their external supporters (the US, the UK and France) may not deter future attacks on the Islamic Republic, Tehran sought to develop missiles with greater warfighting capacity by improving missile accuracy.

[37] CSIS Missile Defense Project, "BrahMos", in *Missile Threat*, last modified 15 June 2018, https://missilethreat.csis.org/missile/brahmos.

[38] Rajat Pandit, "India Successfully Tests Its First Nuclear-Capable Cruise Missile", in *The Times of India*, 8 November 2017, http://toi.in/E_MCYa/a24gk.

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Iran has made substantial strides in developing precision-guided, aero-ballistic missiles,[39] since it began prioritising accuracy. Progress has been evolutionary, beginning with the third and fourth generation versions of the solid-fuel Fateh-110, whose range had increased to 300 km. By 2015, Iran had developed and introduced the 500 km range Fateh-313, followed by the 750 km range Zolfaghar in 2016 and the approximately 1,000 km range Dezful in 2019. In 2020, Iran tested the Haj Qasem missile, claiming it could reach as far as 1,400 km. In January 2020, Iran demonstrated the Zolfaghar's accuracy under battlefield conditions when it succeeded in damaging several key buildings at the US-operated Al Asad airbase in Iraq. It is unclear if the Dezful and Haj Qasem missiles are as accurate as the Zolfaghar, but it seems likely that these solid-fuel systems are considerably more precise than their liquid-fuel counterparts.

Iran has publicly and repeatedly stated that it does not need missiles that can reach beyond 2,000 km. However, if Iran elects to extend the reach of its missiles, it has three viable options. The Khorramshahr is powered by engines imported from North Korea, the same engine used by Pyongyang's failed Hwasong-10 (Musudan) IRBM. It is unclear if Iran will succeed in overcoming the technical and equipment challenges that doomed the Hwasong-10. Alternatively, Tehran might have access to the RD-250 engine technology that North Korea used to build its Hwasong-12 IRBM and Hawasong-14 and 15 ICBMs.[40] Finally, Iran could build on its progress on solid-propellant motor production to create boosters large enough to serve as a first stage of an IRBM or ICBM. Such developments would require years of effort and a long-term financial commitment to succeed.

3.4 Israel

Surrounded by hostile forces since declaring independence in 1948, Israel adopted a long-term approach to address its national security imperatives. A key element of this strategy was laying the scientific and technological foundation for its military development and acquisition programmes through the creation of the Science Corps, and associated institutes and universities, including Technion and the Weizman Institute. The Science Corps, which later morphed into the National Weapons Development Authority, or Rafael, was assigned, amongst other tasks, responsibility for the development and production of Israel's sounding rockets and related missile technologies.[41] The Israeli Aircraft Industry, Israel Military

[39] Aero-ballistic missiles are loosely defined as systems that use flattened trajectories that do not exceede levations greater than about 50 km. The air density below 50 km is dense enough to enable the low-flying missile to maneuver during its entire flight path to the target using aerodynamic surfaces, or adjustable fins. If aided by satellite-navigation receivers, it is possible for the missile to make constant adjustments during flight to achieve great precision.

[40] The United States Department of Treasury levied sanctions against Iran and North Korea for their cooperative work on an "80-ton booster", which is very likely related to RD-250 technology. See: US Department of the Treasury, *Treasury Sanctions Those Involved in Ballistic Missile Procurement for Iran*, 17 January 2016, https://www.treasury.gov/press-center/press-releases/Pages/jl0322.aspx.

[41] Gerald M. Steinberg, "Israel: Case Study for International Missile Trade and Nonproliferation", in William C. Potter and Harlan W. Jencks (eds), *The International Missile Bazaar. The New Suppliers'*

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Industries, and a number of smaller firms specialising in aeronautical engineering, chemistry, metallurgy, electronics and missile guidance were also engaged to support missile and satellite-launcher development.

Israel has leveraged its scientific and technical foundation, in combination with access to foreign aid, expertise, and hardware to develop some of the world's most sophisticated weaponry, including ballistic missiles, as exemplified by the Jericho 1 missile programme. The Jericho 1 could strike targets at a range of roughly 500 km when fitted with a 1,000 kilogrammes (kg) payload, which could be either a conventional, high-explosive warhead or a nuclear one. The missiles could be launched from silos or road-mobile platforms.

The 1,500 km range Jericho 2 reportedly became operational in 1989, in order to reach longer-range targets. Eight test launches were conducted through 2001. The missile is deployed near the town of Zacharia.

Media reports suggest that Israel may have developed a Jericho-3 missile.[42] However, it remains unclear if the flight tests ascribed to the Jericho-3 involved ballistic missiles or satellite launches carried out by Israel's Shavit carrier rocket, which is believed to employ the same (or very similar) solid-fuel motor combination. If the Jericho-3 exists as a military weapon, its range would very likely exceed 5,000 km when fitted with a 1,000 to 1,500 kg payload.

The Jericho missiles are likely nuclear armed. However, Israel appears to view its vaunted air-force and its submarine-launched Popeye-Turbo cruise missile as the preferred means for delivering a nuclear weapon.

Tel Aviv also developed a short-range, road-mobile, solid-fuel missile that can be fired from land- and sea-based launch canisters. With a range of 280 km when carrying a 600 kg payload, the Long Range Attack (LORA) missile employs satellite-navigation receiver to complement its inertial navigation units, resulting in highly precise delivery of its warhead.

In addition, Israel has developed and produced three unique missile-defence systems in cooperation with the US. The Arrow-2 provides defence against short- and medium-range ballistic missiles. An initial Arrow-2 battery was sited at the Palmachim Airbase in 2000, with a second battery positioned outside the city of Haifa in 2002. An enhanced version of Arrow-2 – known as Arrow-3 – can perform exo-atmospheric intercepts of medium-range missiles fired from distances of up to 2,400 km. After completing development in late 2016, the Arrow-3 was declared combat ready in January 2017.

Network, Boulder, Westview Press, 1994, p. 235-253.

[42] On the Jericho III/Jericho-3, see: Douglas Davis, "A Must Read about Israel's Military Machine", in *Jerusalem Post*, 9 August 1996.

Israeli industries, in cooperation with the US defence firms, has developed two additional missile defence systems, David's Sling and Iron Dome. David's Sling provides mid-tier defence capacity against short-range ballistic missiles, cruise missiles and heavy artillery rockets. Iron Dome defends against close-range missiles, artillery, and mortar rockets, including the crude but lethal projectiles fired at Israel from Gaza and Southern Lebanon.

3.5 North Korea

North Korea's quest to acquire an indigenous ballistic-missile production capability began in the mid-1970s. Since then, Pyongyang has developed an extensive array of missile systems with an increasingly long range. Like the nuclear programme, the original motivation was to be able both to deter and to coerce. The main objectives today most likely include a credible capacity to engage targets in the US mainland; greater survivability, precision and lethality of short- and medium-range mobile ballistic missiles; development of a sea-based component; and increasing the ability to penetrate US missile defences.

The core of the North Korean missile arsenal consists of ground-based, road-mobile, liquid-fuel, SRBMs and MRBMs based on Scud technologies. This includes the Hwasong-5 (Scud-B), Hwasong-6 (Scud-C), Hwasong-7 (Nodong), and Hwasong-9 (Scud-ER) missiles. Some of these systems have been modified to extend their range (Hwasong-7, Nodong-II), while others have been fitted with Manoeuvrable Re-entry Vehicles (MaRVs) to improve accuracy to challenge missile defences. Both the Hwasong-6 and -7 have been flight tested with a MaRV warhead.

In 2017, the Democratic People's Republic of Korea (DPRK) test-launched a new single-stage IRBM, the Hwasong-12 (KN-17), a mobile-launched 3,700 km-range missile that can reach not only anywhere in the South and Japan, but US bases on Guam as well. The missile used a new engine that appears to be derived from the Soviet-era RD-250 and produced by the DPRK indigenously using technical documentation received from Ukraine. The system probably served as a technology demonstrator for the first stage of the Hwasong-14 ICBM that was flight tested on July 2017. By some calculations, if the steeply curved trajectory of those tests had been altered to maximise range, the missile could have reached targets lying 6,000 km to 8,000 km away. It means that the Hwasong-14 could be capable of striking Alaska and Hawaii, and probably Seattle. These ranges assume that the warhead would weigh no more than 300 kg, with re-entry vehicle overall mass being about 500 kg. Such miniaturisation does not look very probable today. Carrying a bomb 100 kg heavier, the Hwasong-14's maximum reach is just under 6,000 km.

Given the limited performance of the Hwasong-14, it was not surprising to see the DPRK introduce a larger, longer-range missile: the Hwasong-15, launching it on 2017 on a highly lofted trajectory. If a standard trajectory were used, the Hwasong-15 would be able to travel about 12,000 km, reaching any point on the US mainland if armed with a 1,000 kg payload. However, the DPRK claims that it has a usable arsenal of intercontinental ballistic missiles appear to be premature. The Hwasong-14 and

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Hwasong-15 launches conducted to date were tests involving prototype missiles travelling on inefficient flight paths that do not reflect the operational conditions expected when employed as a weapon system. As of September 2020, neither missile has been tested to its maximum range on a standard trajectory. Based on the North Korean missile industry's previous record, it will take a few years and a handful of additional flight tests under various operational conditions to eliminate these missiles' teething problems and enter them into service with an expectation that they will perform as designed more often than fail if fired during a crisis.

The DPRK has also shown progress in solid-propellant missiles. Shortly after North Korea began launching Toksa missiles in large numbers in 2013, a new, much larger solid-fuel missile was introduced and tested: the medium-range SLBM Pukguksong-1, with an estimated range of 1,200-1,250 km. These missiles are probably intended to provide Pyongyang a future capability to deliver a retaliatory strike. In 2019, North Korea flight tested a two-stage, solid-fuel Pukguksong-3 missile from an underwater launch system on a steep, upward trajectory. According to some estimates, if the Pukguksong-3 had used a standard trajectory, it would have overflown Japan and reached up to 2,000 km. To become operational, the Pukguksong-3 will require additional flight testing of the missile itself, as well as the construction of at least three submarines which would need to undergo sea trials and crew training that may require an additional five to ten years' effort.

Meanwhile, the Pukguksong-1 design is being used to develop the land-based Pukguksong-2 medium-range ballistic missile, which is launched from a canister carried on a tracked chassis for enhanced mobility. Deployment of these missiles, which may be imminent if not already in place, will be a major milestone, allowing the Korean People's Army Strategic Rocket Force (KPASRF) to fire on a target 1,200-1,300 km away within 10-15 minutes of receiving an order. In addition to other advantages that make the new missile easier to operate and to conceal, its tracked chassis provides a greater freedom of manoeuvre off-road.

In 2019, North Korea flight tested two additional solid-fuel, short-range missiles – speculatively designated KN-23, and KN-24 by the US – reaching distances of 400 and 380 km respectively. The emergence of these missiles, in combination with the emergence of the Scud-missiles equipped with MaRVs, provide compelling evidence that Pyongyang continues to seek enhanced military and strategic capabilities, as well as the means to reduce the efficacy of missile defences positioned in South Korea.

Critical questions about Pyongyang's missile arsenal remain unresolved. Given the limited number of flight tests, the operational reliability of North Korea's newer missiles is unknowable. Also unknown is whether North Korea can protect a nuclear warhead from the rigors of re-entry into the Earth's atmosphere at ICBM velocities. Further, questions remain about whether Pyongyang can miniaturise a nuclear warhead sufficiently to place it on top of its advanced missiles.

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Additional testing could help the DPRK fix any problem over time, enabling the full capacity of its many deployed ballistic missiles, from short to intercontinental ranges. Conversely, testing restrictions – whether the result of negotiations or self-imposed – could limit the development of the DPRK's nuclear missile capability.

3.6 Russia

Russia's nuclear strategy during the Cold War was founded on the belief that a large, secure, and reliable nuclear arsenal was required to demonstrate its capacity to punish any potential adversary at unacceptable levels. In Moscow's view, a credible threat or fear of "massive retaliation" is sufficient to deter aggression by its strategic rivals, including the US.

However, developments in the US over the past two decades have driven Moscow to reconsider and rethink some of the core principles that guided its nuclear strategy, force structure, and investment priorities. The two developments that concern Russia's strategic planners the most are Washington's Prompt Global Strike enterprise and the deployment of a homeland missile defences. In Moscow's view, if developed and realised together, a fast-reaction force of conventionally-armed, precision-guided weapons could enable a disarming first strike and the defences could render any surviving Russian nuclear capacity ineffective. Such worries have shaped Russia's strategic weapons modernisation plans, heightened internal debates at the Kremlin over warfighting and deterrence doctrine, and fuelled inter-service and industrial rivalries.[43]

The largest and most valued component of Moscow's nuclear triad remains its land-based, Strategic Rocket Forces (*Raketnye vojska strategičeskogo naznačenija* - RVSN). The RVSN is divided into mobile and silo-based units that are organised together into three Rocket Armies comprised of 12 missile divisions. Eight of the 12 missile divisions are outfitted with road-mobile TEL vehicles carrying solid-propellant ICBMs.[44] Within these divisions are 15 road-mobile regiments equipped with three-stage solid fuel missiles RS-24 Yars (SS-27 Mod 2), forming the backbone of the land-based mobile forces. Each regiment contains nine TELs. Two additional regiments are armed with the solid fuel intercontinental ballistic missiles RS-12M2 Topol-M (SS-27 Mod 1), while three more regiments retain the older RS-12M Topol (SS-25 Sickle). A possible addition to the Yars family is sometimes mentioned in

[43] The development of the nuclear-propelled, long-endurance, intercontinental-range cruise missile 9M730 Burevestnik is an example of industry promoting a pet project that has limited strategic or operational utility, but on the surface appears to address concerns about penetrating US missile defences.

[44] Missile specifications, deployment status, and related information are drawn from three sources, unless otherwise noted: Hans M. Kristensen and Matt Korda "Russian Nuclear Forces, 2019", in *Bulletin of the Atomic Scientists*, Vol. 75, No. 2 (March 2019), p. 73-84, https://doi.org/10.1080/00963402.2019.1580891; Pavel Podvig, "Strategic Rocket Forces", in *Russian Strategic Nuclear Forces*, last modified 4 January 2020, http://russianforces.org/missiles; IISS, "Russian Military Modernisation: A Net Assessment", in I*ISS Strategic Dossiers*, 2020, Ch. 2.

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the Russian media, the Yars-M, although its status is uncertain.[45] The fielding of three unique road-mobile ICBMs raises concerns about procurement and maintenance efficiencies and, more importantly, issues of inter-operability, since the communications and battle-management systems likely differ across the three.

As of late 2019, three regiments of RS-18 (SS-19 Stiletto) and eight regiments of RS-20 (SS-18 Satan) silo-based ICBMs were fielded by the RVSN. These legacy systems have had their service life extended as the development of intended replacements slipped. Although most will be withdrawn from service in the next few years, some RS-18s are being retained as a launch system for the Avangard hypersonic boost-glide vehicle. The maritime leg of the triad is also a mix of recently introduced and legacy systems. SSBNs are divided between the Northern and the Pacific Fleets. Of the Navy's 11 SSBNs, plus a single Project 941 Akula (Typhoon) in reserve, eight are with the Northern Fleet and three with the Pacific Fleet.

The Delta III SSBN carries 16 liquid-fuel R-29RKU-02 Stantsia-02, an upgraded variant of the SS-N-18 Stingray, while the Boreys each carry 16 of the new 3M30 Bulava (SS-N-32) solid-fuel missiles. The Northern Fleet operates one Borey and one improved Project 955A Borey-A, alongside six Project 667BDRM Delfin (Delta-IV) submarines. Each of the Delfins can carry 16 R-29RM-series (SS-N-23) liquid-fuel SLBMs. These are a mix of the R-29RMU Sineva and the R-29RMU2.1 Layner. 108 SLBMs were delivered between 2012 and 2018, and ten Bulava SLBMs were due to arrive in 2019.[46] There is no official public data on warhead numbers and types, however there may be some "universal" options, including for the Bulava and Yars "families" of solid-fuel ballistic missiles.

Russia deploys the A-135 (ABM-4 Gorgon) missile defence systems around Moscow to intercept long-range ballistic missiles. The system was last tested in 2017 and remains operational. Russia's theatre-level missile defences are provided by the Air Defence regiments equipped with S-300PMU2 (SA-20 Gargoyle) and S-400 (SA-21 Growler) batteries.

3.7 South Korea

The Republic of Korea (ROK)'s interest in ballistic-missile development can be traced back to the mid-1970s, when it modified, tested, and deployed US-supplied Nike Hercules AMD systems.

The rapid pace of nuclear and ballistic missile testing by North Korea under Kim Jong Un, began in 2012, significantly heightened South Korea's threat perceptions.

[45] "Raketnyy polk na Altaye perevoorushili na novyye kompleksy 'Yar-S'", in *RIA Novosti*, 27 December 2019, https://ria.ru/20191227/1562950140.html.

[46] Russian Ministry of Defence , *Tezisy doklada zamestitelya Ministra oborony Rossiyskoy Federatsii Aleksseya Krivoruchko no Edinom dne priyemki voyennoy produktsii 12 aprelya 2019 goda*, 12 April 2019, https://function.mil.ru/news_page/person/more.htm?id=12225535@egNews.

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Faced with an imminent and existential threat from the North, Seoul established a "three-axis" strategy to deter Pyongyang's use of nuclear-armed ballistic missiles and, should deterrence fail, minimise their damaging effects.[47] In January 2019, the three-axis strategy was re-introduced as a "nuclear-Weapons of Mass Destruction (WMD) response system". The components underpinning the strategy have been renamed. Korean Air and Missile Defense (KAMD) has been changed to "Korean missile defence", Kill Chain is now "strategic strike system" and Korean Massive Punishment and Response (KMPR) has become "overwhelming response capabilities". Korean missile defence is founded on indigenously developed and imported systems that detect, track, and intercept ballistic missiles launched by North Korea. Initially, the system was enabled by 48 Patriot Advanced Capability-2 (PAC-2) interceptors, although the number would ultimately grow to 300. Seoul upgraded its capabilities in 2014 by purchasing 136 Patriot Advanced Capability-3 (PAC-3) interceptors.

The ROK is continuing its effort to develop indigenously its own missile-defence system, the Medium-range Surface-to-Air Missile (M-SAM), whose overall capabilities are like those of the PAC-3. Seoul also has a longer-range missile-defence system – the Long-range Surface-to-Air Missile (L-SAM) – under development. When operationalised, the L-SAM will provide a layered defence network capable of greater efficiencies than a single-tier architecture.

The two other components of South Korea's strategy – the "strategic strike system" and the "overwhelming response capabilities" – are enabled by Seoul's development and acquisition of precision-guided ballistic and cruise missiles.

South Korea presently deploys two solid-fuel ballistic missiles, the Hyunmoo-2A and Hyunmoo-2B, that can strike targets accurately. The Hyunmoo-2A is a single-stage system with a range of 300 km.[48] The Hyunmoo-2B is two-stage missile with a range of 500 km, when armed with a 1,000 kg warhead, but it can reach targets up to 800 km with a reduced payload. The Hyunmoo-2C is under development and is expected to have an 800 km range with an unspecified payload mass. Seoul's ballistic missiles are supported by three turbojet powered cruise missiles: the Hyunmoo-3A, -3B, and -3C, with ranges of 500 km, 1000 km, and 1,500 km respectively, when carrying a 500 kg payload.[49] All South Korean missiles are conventionally armed.

[47] Jun Ji-hye, "3 Military Systems to Counter N. Korea: Kill Chain, KAMD, KMPR", in *The Korea Times*, 1 November 2016, https://m.koreatimes.co.kr/pages/article.asp?newsIdx=217259.

[48] "Nike-Hercules Variant (NHK-1/2 or Hyon Mu 1 and 2)", in James C. O'Halloran (ed.), *IHS Jane's Weapons: Strategic 2015-2016*, Coulsdon, Jane's Information Group, 2015, p. 68-69.

[49] CSIS Missile Defense Project, "Missiles of South Korea", in *Missile Threat*, last modified 30 July 2020, https://missilethreat.csis.org/country/south-korea.

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4. Europe's missile defence: NATO role and EU contribution

by Alessandro Marrone

4.1 NATO's fundamental role for Europe's missile defence

As mentioned in previous sections, the Atlantic Alliance does play a fundamental role for Europe's missile defence through the NATO IAMD. It is a continuous mission in peacetime, crisis and conflict time, to protect the territory and population of European members. Allied IAMD incorporates all measures to deter and defend against any air and missile threat, under the military authority of the Supreme Allied Commander Europe (SACEUR).[50] It is implemented through a network of interconnected national and NATO systems comprising sensors, Command and Control (C2) facilities and weapons. Here, integration is an essential requirement because it provides coordination and synchronisation of all necessary and available capabilities – which should obviously be fully interoperable.

IAMD encompasses missile defence, which covers both NATO forces deployed in operational theatres against short- and medium-range ballistic missiles – through the Active Layered Theatre Ballistic Missile Defence (ALTBMD) – and the territory of European members.[51] Actually, the ALTBMD represented the Alliance's first initiative in this domain, launched in 2005 to integrate national capabilities into a common battle management system, initially focused on short- and medium-range threats.[52] Concerning in particular Europe's missile defence, in 2010 the Allies decided to develop a territorial BMD capability as part of NATO's core task of collective defence.[53] Six years later, they achieved the Initial Operational Capability (IOC) of NATO's BMD. As stated by NATO's 2012 Defence and Deterrence Posture Review, missile defence can complement the role of nuclear weapons in allied deterrence without substituting them, and it is a purely defensive capability.

The main pillar of allied BMD is the US' European Phased Adaptive Approach (EPAA). An American radar system is hosted in the Turkish base of Kurecik, while US Aegis system and Standard Missile-3 (SM-3) effectors are located in the Romanian Deveselu air base, as well as in the four destroyers home-based in the Spanish port of Rota. Namely, the Romanian Aegis Ashore site includes 24 SM- 3 interceptors.[54]

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[50] NATO, *NATO Integrated Air and Missile Defence*, last updated 15 April 2019, https://www.nato.int/cps/en/natohq/topics_8206.htm.

[51] "Missile Defence", in *NATO Review*, https://www.nato.int/docu/review/Topics/EN/Missile-defence.htm.

[52] Michele Nones, Paola Sartori and Andrea Aversano Stabile, "La difesa missilistica e l'Italia: vecchie minacce e nuove sfide per la sicurezza nazionale", in *Documenti IAI*, No. 19|17 (September 2019), p. 25, https://www.iai.it/en/node/10712.

[53] NATO, *Ballistic Missile Defence*, last updated 9 October 2019, https://www.nato.int/cps/en/natohq/topics_49635.htm.

[54] Ian Williams, "Achilles' Heel. Adding Resilience to NATO's Fragile Missile Shield", in *CSIS Briefs*, August 2019, https://www.csis.org/node/53584.

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The command centre is hosted at the German Ramstein Air Base.[55] As of 2020, a second Aegis Ashore site is being constructed near Redzikowo, Poland. Polish and Dutch governments have also decided to procure frigates equipped with radars able to contribute to BMD.[56] Moreover, several Allies currently provide ground-based AMD systems such as SAMP/T and Patriot, or complementary ships as a force protection of other BMD assets.[57] The current NATO architecture's reliance on the Kurecik radar as main element to detect a missile launch in the Middle East represents a weakness, since its malfunctioning or destruction would jeopardise the whole missile defence capability against Iranian threats.[58] Aegis sites are equipped with their own radars and data could come from other allied sensors; still, the overreliance on Kurecik component somehow constitutes the Achille's heel of NATO BMD towards Teheran.[59]

Within the Alliance, the Defence Policy and Planning Committee (DPPC) on Missile Defence oversees and coordinates all efforts at the politico-military level to develop this capability. NATO investments are significant: since 2016, over 1.1 billion US dollars have been invested to develop an open C2 architecture able to coordinate all assets procured by member states that are interoperable and relevant for missile defence.[60] The programme, managed by the NATO Communications and Information Agency (NCIA), is particularly relevant in this regard.[61] C2 is obviously important for all operations, but it is particularly vital for BMD to properly function, as sensors and interceptors are nationally owned and spread across a vast geographic area.[62] Noticeably, interoperability does not necessarily require common military equipment: what is important is that these assets are able to communicate and share information with other systems.[63] At the same time, multinational procurement greatly contributes to both interoperability and capability development, as it splits the research and development costs of expensive equipment among Allies, and involved parties can maximise usage and share technical expertise by working together to acquire and operate missile defence technology.[64]

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[55] The Ramstein Air Command has been responsible also for the C2 of the missile defence assets deployed by the US, Germany, Italy, Spain and the Netherlands in Turkey within NATO's operation Active Fence.

[56] Richard King, "Improving Ballistic Missile Defence Interoperability", in *JAPCC Journal*, No. 28 (June 2019), p. 51-55, https://www.japcc.org/improving-ballistic-missile-defence-interoperability.

[57] NATO, *Ballistic Missile Defence*, cit.

[58] Ian Williams, "Achilles' Heel", cit.

[59] Ibid.

[60] Vivienne Machi, "NATO Missile Defense Systems Strive for Interoperability", in *National Defense*, 31 July 2017, https://www.nationaldefensemagazine.org/articles/2017/7/31/nato-missile-defense-systems-strive-for-interoperability.

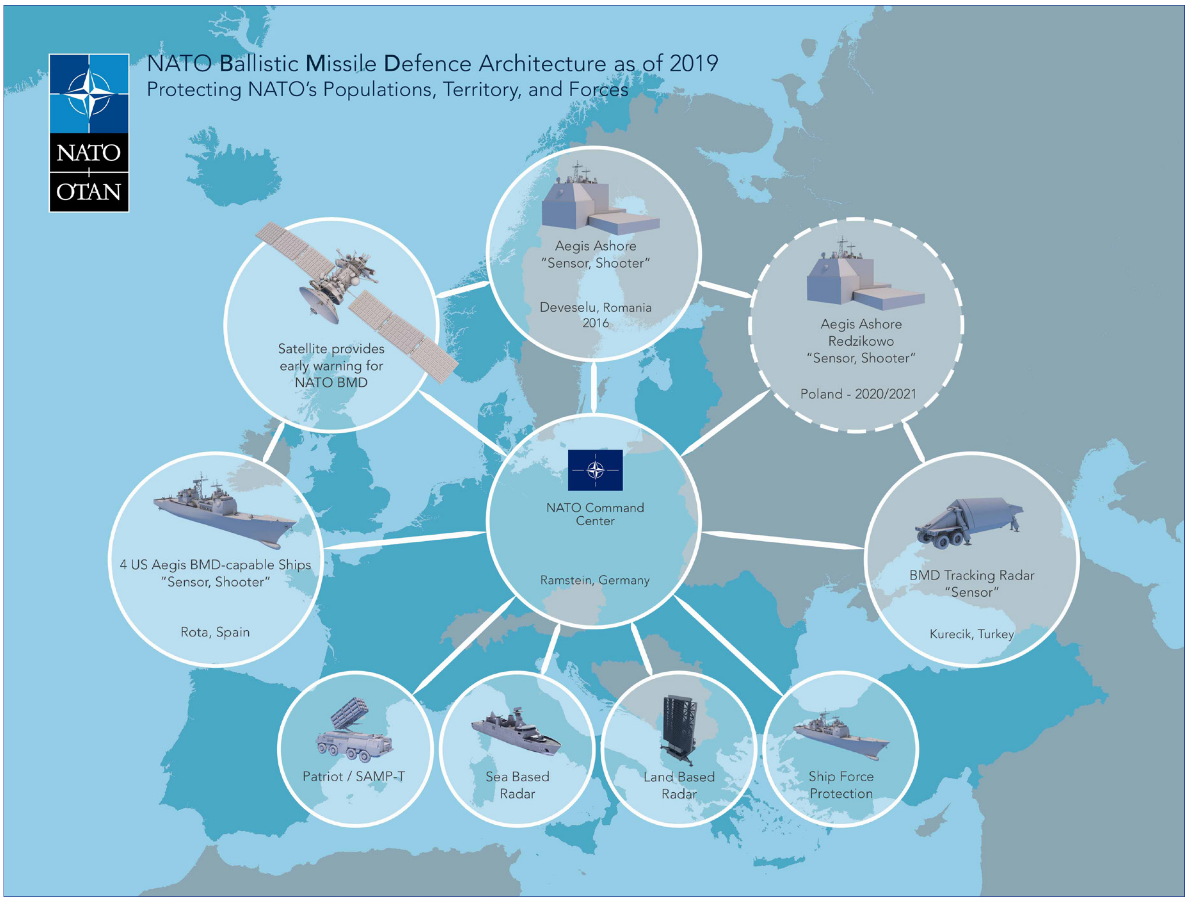
[61] NATO Communications and Information Agency (NCIA), *NATO's Ballistic Missile Defence Programme Gets a Makeover*, 25 November 2019, https://www.ncia.nato.int/about-us/newsroom/natos-ballistic-missile-defence-programme-gets-a-makeover.html.

[62] Richard King, "Improving Ballistic Missile Defence Interoperability", cit.

[63] Ibid.

[64] Ibid.

Figure 1 | NATO BMD architecture (2019)



Source: NATO, *NATO Ballistic Missile Defence*, last updated 2 May 2019, https://www.nato.int/cps/en/natohq/photos_112331.htm.

As missiles are one of the main delivery systems for nuclear weapons, allied BMD is structurally linked to NATO nuclear deterrence. On June 2020, the allied ministerial meeting addressed Russia's extensive and growing arsenal of nuclear-capable missiles[65] and their implications on the Allies' security. Secretary General Jens Stoltenberg noted that the 2019 deployment of SSC-8 missiles by Russia led to the demise of the INF Treaty, stressing that they are dual-capable, mobile, hard to detect, and able to reach European cities with little warning time.[66] The Secretary General also repeatedly warned that Russian renewed missile arsenal does lower the threshold for the use of nuclear weapons.[67] Moreover, in December

[65] On Russia, see Section 3.

[66] NATO, *Press Conference by NATO Secretary General Jens Stoltenberg following the Meetings of NATO Defence Ministers*, 17 June 2020, https://www.nato.int/cps/en/natohq/opinions_176520.htm.

[67] Jens Stoltenberg interview with Markus Becker and Peter Müllerin, "The New Russian Missile Systems Are Highly Dangerous", in *Der Spiegel*, 25 February 2020, https://www.spiegel.de/international/world/nato-secretary-general-stoltenberg-the-new-russian-rockets-are-highly-dangerous-a-03961e64-48b7-43f3-84eb-16acef38cd69.

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2019, Russia's new Avangard hypersonic delivery system became operational.[68] As of 2020, NATO's response to Moscow consists in strengthening its IAMD, also through the acquisition of new Patriot and SAMP/T batteries. The Alliance's Nuclear Planning Group (NPG)[69] has decided to maintain current nuclear sharing arrangements without deploying new land-based nuclear missiles in Europe, with the aim to avoid an arms race.[70] This decision places even greater importance on IAMD as the cornerstone of the whole NATO deterrence and defence posture across the conventional-nuclear continuum.

4.2 EU contribution to Europe's missile defence

Within the recent EU initiatives aimed at moving defence cooperation and integration forward, missile defence has been considered for the first time in the Union's history. As mentioned in previous sections, the TWISTER PeSCo project aims at strengthening the ability of Europeans to better detect, track and counter missile threats through a combination of enhanced capabilities for space-based early warning and endo-atmospheric interceptors.[71] Launched by France, Finland, Italy, Spain and the Netherlands under French leadership, in Autumn 2020 it saw Germany joining the project.[72] That means TWISTER is currently participated by the four EU members with the greatest military budgets and the largest defence industrial base.[73] Germany's latest announcement in favour of capabilities against hypersonic weapons[74] is particularly interesting, in light of Berlin's central position in geographic and budgetary terms. Moreover, Berlin is going to decide soon whether to continue the TLVS procurement programme, which some experts consider complementary to TWISTER[75] but see Lockheed Martin as prime contractor – with MBDA Germany as a partner.

By bringing together space-based early warning systems and endo-atmospheric interceptors, the PeSCo project has a significant potential against a broad range of threats, particularly concerning hypersonic missiles and gliders. Indeed, space-based, long-range radars are crucial to anticipate and improve the detection and tracking of hypersonic delivery systems which, due to their features, are likely

[68] See in this regard Section 3.

[69] The Nuclear Planning Group includes representatives from 28 NATO members, while France decided to not participate in the Group.

[70] NATO, *Press conference by NATO Secretary General Jens Stoltenberg...*, cit.

[71] PeSCo website: *Timely Warning and Interception with Space-Based Theater Surveillance (TWISTER)*, cit.

[72] Artie Villasanta, "EU Project to Build Hypersonic Missile Defense Now Includes Germany", in *Business Times*, 1 December 2020, https://www.btimesonline.com/articles/142970/20201201/eu-project-build-hypersonic-missile-defense-now-includes-germany.htm.

[73] They also represent three out of the four home-countries for MBDA and its subsidiaries.

[74] Artie Villasanta, "EU Project to Build Hypersonic Missile Defense Now Includes Germany", cit.

[75] Sebastian Sprenger, "Germany Joins Nascent European Push to Shoot Down Hypersonic Missiles", in *Defense News*, 30 November 2020, https://www.defensenews.com/global/europe/2020/11/30/germany-joins-nascent-european-push-to-shoot-down-hypersonic-missiles.

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to need interception within the Earth atmosphere. Once developed, ideally by 2030, TWISTER capabilities would serve the dual purpose of enhancing European contribution to NATO’s IAMD and increase the EU’s level of strategic autonomy when it comes to missile defence.[76] This kind of initiatives is important not only to share costs among participating countries – and eventually to benefit from EU co-funding – but also to increase interoperability among concerned militaries, through common operational requirements, testing and certification.[77] As the development of a high-end interceptor is particularly demanding, it also represents the drive for a qualitative leap forward of the European defence industry’s missile sector.[78] For instance, an endo-atmospheric effector needs to breathe relatively dense air and its sensors should be able to handle the heat of air friction.[79] In other words, Europe is lagging behind in this field in comparison with Russia, China and the US,[80] and TWISTER does represent the EU’s flagship project to catch up in this regard.

Other recent European defence projects are, to a certain extent, related to missile defence. Firstly, within PeSCo, the European Military Space Surveillance Awareness Network (EE-SSA-N) initiative led by Italy and participated by France, Germany and the Netherlands aims to develop an autonomous, sovereign EU military Space Situational Awareness (SSA) capability that is interoperable, integrated and harmonised with the EU Space Surveillance and Tracking (SST) Framework initiative for the protection of European space assets and services.[81]

Secondly, within the European Defence Industrial Development Programme (EDIDP), the call “SSAEW-2020 - Space Situational Awareness and Early Warning capabilities” includes, as a sub-topic, “early warning against ballistic missile threats through initial detection and tracking before handing over to ground-based radars”. As such, this EDIDP call represents an opportunity for EU co-funding for the space-based early warning component of missile defence architectures – which is a promising element of TWISTER – and, broadly speaking, for European cooperation in this regard. Moreover, from 2021 onwards, the European Defence Fund (EDF) will probably feature calls to finance technological development related in various ways to missile defence, and projects eligible for EDF funding could stem from TWISTER, too.

[76] “EU Ballistic Missile Defence”, in *Defence Procurement International*, 18 November 2019, https://www.defenceprocurementinternational.com/features/air/multi-role-interceptor-for-eu-missile-defence.

[77] Michele Nones, Paola Sartori and Andrea Aversano Stabile, “La difesa missilistica e l’Italia”, cit., p. 26.

[78] “MBDA nel progetto missilistico europeo TWISTER”, in *Analisi Difesa*, 16 November 2019, https://www.analisidifesa.it/?p=129288.

[79] David Axe, “Europe Wants Its Own Anti-Nuclear Ballistic Missile Defense System”, in *The Buzz*, 18 March 2020, https://nationalinterest.org/node/134317.

[80] Audrey Quintin and Robin Vanholme, “Hypersonic Missiles and European Security: Challenges Ahead”, in *Finabel*, 28 July 2020.

[81] PeSCo website: *European Military Space Surveillance Awareness Network (EU-SSA-N)*, https://pesco.europa.eu/project/european-military-space-surveillance-awareness-network-eu-ssa-n.

Finally, contributions to the broader missile defence architecture are emerging indirectly, through innovative programmes on persistent ISR, network centric operations, and future navigation technology, namely the European High Atmosphere Airship Platform (EHAAP), the EU Collaborative Warfare Capabilities (ECoWAR), and the EU Radio Navigation Solution (EURAS).[82]

[82] See in this regard Section 5.

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5. France

by Stéphane Delory[83]

5.1 Strategic and defence policy issues

France's approach to missile defence is paradoxical. For a very long time, the French authorities perceived the concept of missile defence essentially from a strategic angle. They identified it as a factor that undermines the effectiveness of nuclear operations and, in parallel, as one unable to protect the territory and the population successfully. Following this approach, missile defence had a threefold disadvantage. Firstly, it contributed to eroding the principles of assured destruction and mutual vulnerability, which are cornerstones of the offensive nuclear deterrence. Secondly, it compelled nuclear powers to modernise and to constantly increase their offensive and defensive components, thus leading to an unsustainable increase in the cost of deterrence. Thirdly, as a result, it generated a structural strategic instability. Accordingly, for a long time, French political and military leaders tended to perceive missile defence exclusively within the framework of the strategic balance between nuclear powers, underestimating the role it could play for some of its partners to strengthen the extended deterrence, but also to reassure allies confronted with proliferating states. In 1991, the first Gulf War contributed to accelerating a shift towards the acceptance of point anti-ballistic defences, deemed technically feasible at acceptable costs. Nowadays, the French posture has considerably evolved and is totally supportive of NATO's stance. Nonetheless, missile defence is still perceived as much a political tool as a military one.

Despite this relative mistrust with the concept of missile defence, France is one of the countries in Europe with the greatest expertise on the subject, both in terms of technology and industrial know-how, as well as in terms of concepts (although no dedicated doctrine has been laid out). The development SAMP/T with Italy, and of the Principal Anti-Air Missile System (PAAMS) naval weapon system with Italy and the UK, gave France an initial missile defence capability, independent from US technologies and capabilities. The SAMP/T is an air defence and anti-ballistic weapons system, whereas the PAAMS is deprived of anti-ballistic capabilities, but it is effective against anti-ship missiles and provides area defence against air threats. These systems quite precisely reflect the French approach to missile defence, perceived as an extension of air defence, and not as a specific mission.[84] Paradoxically, while France possesses a missile defence and is at the vanguard of the related technology development in Europe, it has long been reluctant to

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[84] Extended Air Defence (*Défense Aérienne Elargie* - DAE): born partly out of budgetary constraints – given that developing dedicated interceptors and sensors for each mission was far too expensive – this approach represents nowadays one of the major lines of development for all missile defences throughout the world and partially converges with the US concept of IAMD.

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endorse any formalisation of this specific mission within its military forces.

Though this paradox is usually explained by doctrinal considerations, practical constraints also justify the French approach. Due to its costs, missile defence can only partially protect any targeted objective, and most of the missile defence mission is realised either through deterrence (including, first and foremost, conventional deterrence) or through counter-air and counter-strikes operations. From this perspective, missile defence is much more than the mere interception of a missile, and requires the development of a wide range of military capabilities, but also proactive diplomatic initiatives. Moreover, technically speaking, intercepting long-range missiles induces the deployment of exo-atmospheric architectures which, up until now, have been built and controlled by the US. Against this backdrop, preventing the deployment of architectures where European industries and political authorities would be deprived of control or even access has been a constant preoccupation in Paris. France admits that NATO's EPAA is essential to ensure a comprehensive missile defence, contributing to protect the European territory, but wishes to retain some political control, and refuses to finance it at the expense of other capabilities. From this perspective, France has been rather coherent, and has tried to develop some in-house capabilities in fields where dependence on NATO assets were deemed excessive and national industries where able to develop solutions such as early warning. This duality has not prevented Paris from investing massively in NATO programmes, its industries being closely involved in the development of the Air Command and Control System (ACCS), which is a central element of NATO's future IAMD systems. France is also very active in promoting initiatives to enhance surveillance and engagement capability of existing NATO search and fire control radars through the creation of clusters (e.g. on multi-sensors cooperation) – initiatives that were endorsed by the NATO Industrial Advisory Group (NIAG) in 2017. On the other hand, like many other Western countries, France has largely underestimated the so-called Guided/Rocket, Artillery and Mortar (G/RAM) threats as well as the resurgence of air threats, and is currently being forced to develop solutions for Counter-G/RAM (C-G/RAM), Counter-Precision-Guided Munition (counter-PGM), and Counter-Unmanned Aerial Vehicles (C-UAVs), as a matter of urgency. In France, as elsewhere in Europe, both missile defence and extended air defence are not yet fully perceived as budgetary priorities, despite some improvements.

5.2 Military issues

Overview of the systems in use

French missile defence is part of the surface-to-air defence, which is under the sole authority of the Air Force (*Armée de l'Air*). The Air Force uses Crotale NG[85] for short-range air defence, and SAMP/T for medium-range air defence and ballistic

[85] Short-range missiles called Crotale NG have no anti-ballistic capability and are essentially air defence weapon systems. 12 battery are deployed.

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interception. The Army (*Armée de Terre*) deploys very short-range weapon systems, essentially for self-defence or point defence. Currently, the Army is deprived of any missile defence capability, notably against precision guided munitions or G/RAM, but it is likely to be modernised in the next 5 to 10 years. The Navy (*Marine Nationale*) is responsible of air defence for naval operations and is equipped with Aster 15 and Aster 30 for short and mid-range air defence (including cruise and anti-ship missiles but excluding ballistic missiles).

At the time of writing, the two missile defence systems deployed are the SAMP/T (Air Force) and the PAAMS (Navy), both using Aster 30 interceptors. Quite paradoxically, the sensors deployed on the naval units – multifunction EMPAR radar on the French and Italian ships, and SAMPSON on the British ships, associated on both ships with a long-range S1850 search radar – are better adapted to long-range missile detection than the sensor used on the SAMPT/T. Indeed, the latter is deprived of a long-range sensor and relies essentially on the Arabel multifunction radar, which is first and foremost a fire control radar. Tests carried out on the S1850 by several European Navies also showed that naval radar components can be effectively combined with American Aegis/SM-3 architectures for surveillance and data sharing, opening the way to more extensive cooperation with the US in this field. The deployment of a naval anti-ballistic capability will only be achieved with the use of the new iteration of the Aster missile, which will be coupled with a new generation of multifunction radars currently under development.[86] French and European Navies will also have to assess how their existing and future capabilities can be integrated or could complement the US distributed architecture Naval Integrated Fire Control-Counter Air (NIFC-CA), which currently appears to be the sole means by which to mitigate the risk of highly-supersonic and hypersonic anti-ship missiles.

The role of SAMP/T

In terms of anti-ballistic defence, the mission of SAMP/T was defined by the *Direction Générale de l'Armement* (DGA)[87] as a "[weapon] system for the anti-air defence of large Army units, and for the defence of the Air Force's sensitive points, which provides area land defence against all types of modern air targets, including tactical ballistic missiles of the Scud type and cruise missiles, [...]. The SAMP/T [...] provides battlefield air defence, Land Task Force (LTF) protection, air base and fixed-point defence."[88] Concerning ballistic defence, the system is optimised for the interception of SRBMs with a range of 600 km. Though the range of the missile against aircrafts is about 100 km, it is much shorter against ballistic missiles, essentially allowing coverage of very small geographical areas. Quite logically, the eight deployed batteries are essentially used for the protection of sensitive sites. Batteries are air-transportable, but France has been very reluctant to deploy them

[86] The Sea Fire 300 is the radar currently retained.

[87] DGA is the French Programmes Development and Acquisition Agency.

[88] DGA portal ixarm.com: *Présentation*, 21 July 2011, http://www.ixarm.com/en/node/328028.

abroad, due to their scarcity but also due to the political significance of such a deployment. The SAMP/T is also a contribution to NATO ALTBMD.

The SAMP/T is integrated within the French air operations C2 system, which also manages all the air surveillance and air defence sensors. The lack of early warning radar means that France has to rely on NATO assets (Shared Early Warning - SEW) for ballistic warning. The use of link 16, validated in 2015 on the SAMP/T and the current deployment of ACCSs on national territory, allow a more-or-less seamless integration in NATO's architecture.

Because of its limitations against MRBMs and maneuvering targets, a modernisation of the SAMP/T was quickly envisaged, focusing on an upgrade of the missile (Aster-30 B1NT) and the conception of a new radar. Despite the lack of a long-range search and acquisition radar on the SAMP/T, French authorities decided not to supplement the system with a complementary radar, and chose to modernise the whole weapon system around a major upgrade of the interceptor (Aster 30 B1NT) and a new radar (probably a Ground Fire 300) in the 2020s. The goal is to have a coherent architecture capable of engaging threats with a range of 1500 km and shorter-range maneuvering missiles. The modernisation of the missile was formally initiated in 2015, and Italy joined the programme one year later. The decision on the radar is still underway.

The French Navy's missile defence should follow the same process (Italy has already retained the Aster B1NT for its Navy) with interesting outcomes: the system will be able to intercept ballistic and quasi-ballistic targets,[89] but also low altitude anti-ship supersonic missiles, through a simplified architecture. The real challenge for France will be to define an architecture that is able to complement those that are currently being developed for the Aegis weapon-system, notably the NIFC-CA, which is optimised for air-defence and anti-ship interception missions. Since several European Navies are equipped with European sensors well-fitted for missile defence operations, this is clearly a field of cooperation within Europe and with the US.

The development of exo-atmospheric interceptors (Exoguard, for instance) has been considered in the past, but never funded. These projects are unlikely to resume, since that endo-atmospheric threats, notably hypersonic missiles, are perceived as dominant in the near future.

The French paradox

The issue of sensor modernisation and architecture development is emblematic of French contradictions on missile defence, where a real strategic vision coexists with an inability to evaluate military perspectives in concrete terms, leading to

[89] Missiles whose trajectory is largely endo-atmospheric, allowing them to maneuver during their flight and not only in the terminal phase of the flight, as maneuvering warheads.

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somewhat *ad hoc* developments. The early warning demonstrator named *Système Préparatoire Infra-Rouge pour l'ALErte* (Preparatory System for Infra-Red Early Warning - SPIRALE), which has shown an unsuspected potential, was terminated early in the 2010s. The *Très Longue Portée* (Very Long-Range - TLP) radars, which should have provided a ground warning capability in early 2020, have essentially served as a technological testbed for future systems. As a result, industries have been left without commands on crucial technologies for around ten years. Also illustrative of the French paradox, France is one of the few countries in Europe which has developed a demonstrator of BMD C2, IDEFIX, allowing for simulating ballistic strikes and interception on a strategic level, reflecting France's awareness of missile defence issues.[90]

A worrying issue concerns the lack of a strong state commitment to modernise missile defence architectures for the ground component. While this approach is coherent with the integration of French AMD within NATO architectures, the ground component still tends to be considered an addition of stand-alone assets plugged into a static architecture, rather than a dynamic system of systems, including in terms of future operational concepts. Admittedly, some positive evolution is perceivable for the naval component, whereas the leading role of France in the TWISTER programme shows a very positive evolution in the perception of architectures and their critical impact on missile defence effectiveness.

5.3 Industrial and cooperation issues

In terms of future development, industry currently represents France's greatest asset because of its technological capabilities, its ability to understand the evolving missile defence environment, and its multinational dimension. French industry is a major player in the field of missile defence, with numerous firms such as MBDA France, Thales, and the French part of Airbus Defence and Space, all of which also cooperate with their European or American counterparts. The creation of a joint venture between Thales and Raytheon (TRS) or Thales and Airbus (Moss SAS) and the setting up of the Eurosam consortium to market the Aster interceptor and its architecture, illustrates the ability of French industries to establish international cooperation. Another typical example is Roxel, a result of a merger of French and British companies and now owned by MBDA and Safran Ceramics, which has become the world's third largest group for tactical propulsion and designs the propulsion of the Aster. At the same time, the long-term research work carried out by the state research agency ONERA (*Office National d'Études et de Recherches Aérospatiales*) and its close association with national industries, simultaneously

[90] "The French Ministry of Defense (DGA, DGRIS, EMA) has developed a functional demonstrator of the C2 BMD named 'IDEFIX' in a fashion of studying the operation concepts of anti-ballistic missile defense of territories and populations, to evaluate the operational planning concepts [...] and of driving operations by integrating political directives to different strategic, operative levels of interoperability in an autonomous mode or coordinated with the C2 BMD of NATO)". See: Luc Dini, "Integrated Air and Missile Defense (IAMD) in Europe: Complexity, Consensus and New Challenges", in *CEAS Quarterly Bulletin*, June 2017, p. 6-17 at p. 12.

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fosters the emergence of innovative technology solutions. The association between ONERA and industry is particularly strong for propulsion technologies – especially ramjets – but also for radar technologies, high-tech ceramics, simulations, aerodynamics etc.

As indicated above, exo-atmospheric interception technologies and, at the lower end of the spectrum, Counter-Rocket, Artillery and Mortar (C-RAM) systems, remain underdeveloped. However, these shortcomings are manageable. First, the catch-up on C-RAM is not a fundamental technical challenge and some solutions have already been proposed by industry, in France as in Europe. Second, the current and foreseeable evolution of threats tends to place the emphasis on endo-atmospheric interception technologies, where French industry is well positioned. On the contrary, the development of networked sensors, weapons and related systems,[91] and the integration of missile defence as a plain component of the military structures, are issues where industry can provide solutions but France and other European states will need to define concepts, guidelines and budgets to frame future developments. This issue goes far beyond missile defence and cannot be solved through this sole prism.

Integrating missile defence in a European framework is essential, including for Paris. While the French industrial base is highly suited for the development of a modern missile defence, and state authorities are pursuing an ambitious policy through the modernisation of the Aster, France is nonetheless increasingly dependent on European programmes to sustain the development of next generation systems. Paradoxically, it is essentially through the EU's PeSCo projects that elements of solutions are emerging indirectly, through innovative programmes on persistent ISR, network centric operations, and future navigation technology: namely EHAAP,[92] ECoWAR, and EURAS. Elements of solutions are also emerging directly, above all through the TWISTER project, led by France and participated by Finland, Germany, Italy, Netherlands and Spain. TWISTER proposes to develop an endo-atmospheric interceptor able to engage highly supersonic or low hypersonic maneuvering targets and a space-based early warning architecture, which has yet to be defined. Quite interestingly, TWISTER may contribute to the development of a strategic component for a potential European missile defence architecture, transitioning existing European assets – including those developed within NATO – into a much more efficient capability that has not yet been conceived. All these projects will be coordinated by France – except EHAAP, to be coordinated by Italy.

[91] Including the following: transmission of very large data in real time and its redistribution to the wide range of systems, platforms, commands and units; interoperability of future system of systems and their harmonisation throughout their whole operational life; the integration of artificial intelligence within a growing numbers of system of systems.

[92] EHAAP is coordinated by Italy and gathers France and Italy as members.

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France is convinced of the criticality of these programmes, especially TWISTER. Paris is pushing for TWISTER to be integrated in the EDIDP and, ultimately, in the EDF, in order to share the costs. The EDIDP-SSAEW-EW-2020 call, on "Early warning against ballistic missile threats through initial detection and tracking of ballistic missiles before handing over to ground based radars",[93] shows that French preoccupation on early warning and missile defence architectures gathers a growing support in Europe.

This strong stance taken by French industry and the DGA reflects the dynamism of the former, as well as the understanding, both by industrial stakeholders and public authorities, that the very existence of any future missile defence architecture will require extended funding and industrial cooperation at the European level. Some will perceive this positioning as a way to thwart US influence or interests on missile defence in Europe. Although not totally groundless, this kind of assertion misses the point. On the one hand, due to its networked and international dimension, missile defence is an excellent way to promote military and political cooperation and integration, and Europe should use it for its own military construction. On the other hand, states cannot expect to control the constant evolution of missile defence architectures without contributing to their conception and, failing to do so, turn rapidly into mere customers, using a license for weapon systems they no longer completely possess. Lastly, even if missile defence is to be considered only in the NATO framework, European industry will soon be unable to contribute to the transformation of the architecture if it cannot deliver innovative solutions and massively invest in emerging technologies. From this perspective, despite its sometimes irritating posture, France is certainly one of the best advocates for the coherence of missile defence in the Atlantic Alliance.

[93] EDIDP, *2020 Calls for Proposals, Conditions for the Calls and Annexe*, Version 1.2, 23 July 2020, https://ec.europa.eu/research/participants/data/ref/other_eu_prog/edidp/wp-call/edidp_call-texts-2020_en.pdf.

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6. Germany

by Christian Mölling and Torben Schütz[94]

6.1 Political rationale: the European/transatlantic framework

Germany traditionally holds a strong position in NATO's IAMD architecture. Partly, this is a legacy from the Cold War, when stationary AMD systems such as Nike formed the first air defence line of the Alliance along the inner-German border. Another factor is that Germany hosts NATO Allied Air Command at Ramstein Air Base.

While Germany is aware of the changes in the European security landscape since 2014, including the end of the INF Treaty, it is so far unclear if its implications for AMD capabilities really have materialised in the political decision-making in Berlin. Neither an acceleration of longstanding, ongoing procurement processes, nor a re-prioritisation have taken place over the past years.[95] There are, however, early indications that Defence Minister Annegret Kramp-Karrenbauer is taking the matter seriously, as public comments and hints on the importance of future European cooperation in AMD.[96]

In the same vein, past debates about Germany's contribution to NATO missile defence plans for Europe remained rather indecisive. Generally, missile technology proliferation is a matter of growing concern. Regarding the two main reasons for missile defence in the past, nowadays the picture has become worse, firstly with the rising tensions with the primary missile proliferator in the Middle East, namely Iran, and secondly with Russia re-emerging as a military competitor. Yet, Germany has so far only taken political action on the arms control dimension, through diplomatic efforts aimed at devising new arms control agreements on that topic.[97] However, there is no significant debate on missile defence outside military or arms control circles.

While some modernisation efforts of existing systems put a focus on BMD capabilities (e.g. radars on air defence frigates, airspace surveillance radars), it

[94] Christian Mölling is Research Director and Head of the Security and Defense Program at the German Council on Foreign Relations (DGAP). Torben Schütz is Research Fellow for Armament Policy at DGAP.

[95] Interview of the authors with key parliamentarians responsible for the funding of armament projects.

[96] Justyna Gotkowska paraphrasing a tweet from Annegret Kramp-Karrenbauer: "AKK on new generation air defence system: we need to start such a project together in Europe since it is too big to be developed by a single nation. Germany is also increasingly threatened by Russian long-range weapon systems". See Justyna Gotkowska tweet of 15 July 2020 (now unavailable).

[97] See for example: German Federal Foreign Office, *Rethinking Arms Control: The Missile Dialogue Initiative*, 18 October 2019, https://www.auswaertiges-amt.de/en/aussenpolitik/themen/abruestung/missile-dialogue-initiative/2258792.

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will be interesting to see whether recent NATO decisions aiming to strengthen European AMD capabilities[98] will have a more significant impact going forward. This might become more visible once NATO distributes its updated force tables amongst Allies.

Regarding capabilities and procurement, at the moment Germany's focus lies primarily on the routine replacement of two aging AMD systems – the Patriot SAM system and its successor, and the tactical TLVS AMD system;[99] and on initial considerations for the replacement of Germany's current air defence frigates of the SACHSEN-class.[100]

A capability area that has become more acute, however, is the growing threat at the lower end of the spectrum. Here, the proliferation of small commercial UASs used as either intelligence gathering devices or direct munition carriers constitutes a challenge.[101] Consequently, Germany is currently procuring a market-available Very Short-Range Air Defence (VSHORAD) system to equip its forces with a view to the next German lead of the NATO Very High Readiness Joint Task Force (VJTF) in 2023.[102]

Further underlying Germany's political use of its air defence capabilities is the very close cooperation with the Netherlands. In this regard, Project Apollo is key.[103] While its long-term goal is the integration of ground-based air defence capabilities of both countries,[104] it currently entails four core areas of cooperation:
- the joint development of regulations, concepts and doctrines;
- the establishment of a bi-national Air & Missile Defence Academy;
- the subordination of the German Air Defence Missile Group 61 from Todendorf to the Dutch Defence Ground-based Air Defence Command (with a dozen German soldiers on post in the Dutch command);[105]
- the joint development of capabilities in short-range and very-short-range protection.

[98] NATO, *Press Conference by NATO Secretary General Jens Stoltenberg following the Meetings of NATO Defence Ministers by Teleconference*, 18 June 2020, https://www.nato.int/cps/en/natohq/opinions_176561.htm.

[99] André Forkert, "MBDA Presents Its 'Way Ahead'", in *Europäische Sicherheit & Technik*, 9 July 2020, https://esut.de/?p=21588.

[100] Andreas Uhl, "The Next Generation of Air Defense - Preliminary Views on the Frigate F 127", in *Europäische Sicherheit & Technik*, 13 January 2020, https://esut.de/?p=17877.

[101] Christian Mölling, Torben Schütz and Zoe Stanley-Lockman, "A New Dimension of Air-Based Threats", in *DGAP Kompakt*, No. 8 (June 2019), p. 2, https://dgap.org/en/node/32426.

[102] Gerhard Heiming, "Qualified Air Defense - Military Chooses Kongsberg Protector", in *Europäische Sicherheit & Technik*, 4 December 2019, https://esut.de/?p=17234.

[103] Interessengemeinschaft Deutsche Luftwaffe e.V. website: *Projekt Apollo: Deutsch-niederländische Luftverteidigung*, http://www.idlw.de/?p=5910.

[104] German Parliament, *Drucksache 19/3385. Die deutsch-niederländischen Beziehungen*, 12 July 2018, p. 11, http://dipbt.bundestag.de/dip21/btd/19/033/1903385.pdf.

[105] Ibid.

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Nevertheless, the transatlantic dimension is by far the most important one when it comes to AMD: from German dependencies on US hardware (especially effectors) to NATO's IAMD C2 architecture, which is located in Germany. A closer look at the military rationale will underscore this key point.

6.2 Military rationale

Germany's AMD capabilities are defined by quite consistent requirements, namely retaining protection against aircrafts, helicopters, short-to-medium-range ballistic and cruise missiles – both on land and in the sea. In principle, the Federal Republic of Germany performs its air defence tasks in the structures of NATO's IAMD systems. This includes all operational capabilities of the air forces.[106] Additionally, the land domain requires defence against rockets, artillery, and mortar fire. While the degree to which these goals are pursued varies according to the actual missions, the retention of at least a limited number of systems capable of performing the tasks listed above is paramount.

Thus, the German Armed Forces have a mobile VSHORAD system with the Ozelot – a mechanised weapon carrier for Stinger Man Portable Air Defense Systems (MANPADS) – a stationary Forward Operating Base (FOB) defence system for C-RAM tasks (MANTIS), Patriot medium-range SAM units[107] and a dedicated air defence frigate – the F-124 SACHSEN-class.[108] The F-latter has some very limited BMD capabilities, primarily in detection and classification of airborne threats and in engaging tactical ballistic missiles with its SM2 effectors. The planned replacement of its SMART-L radar will constitute one of Germany's contribution to NATO's IAMD in the areas of early warning and targeting.[109] Early warning and C2 components are either integrated into the respective systems on the tactical to operational level, or integrated into respective NATO structures on an operational to strategic level. Most importantly, Germany hosts NATO's Allied Air Command (AIRCOM) at Ramstein Air Base. AIRCOM is in charge of NATO's IAMD systems, which incorporates radar data from airspace surveillance radars all over Alliance territory and provides air command & control and BMD capabilities including data collection, integration and sharing, especially through NATO's ACCS.

Ongoing modernisation efforts of these capabilities seem to be tuned towards a greater awareness of missile threats: from new airspace surveillance radars that

[106] German Parliament, *Drucksache 19/20985. Das Ende des INF-Vertragsund die Zukunft der NATO-Luftverteidigung*, 13 July 2020, p. 3, https://dip21.bundestag.de/dip21/btd/19/209/1920985.pdf.

[107] German Parliament, *Drucksache 18/9265. NATO-Raketenabwehrschirmund NATO-Nuklearstrategieim Umfeld des Warschauer Gipfels*, 25 July 2016, p. 6, http://dip21.bundestag.de/dip21/btd/18/092/1809265.pdf.

[108] Jürgen Mannhardt, "Sea-based Ballistic Missile Defence. German Contribution to a Future European Capabilitiy", in *JAPCC Journal*, No. 26 (Spring/Summer 2018), p. 69-73 at p. 70, https://www.japcc.org/sea-based-ballistic-missile-defence.

[109] Jörg Weber, "Neues Weitbereichsradarfür die Fregatten 124", in *MarineForum*, December 2019, p. 12-13 at p. 12, https://www.dmkn.de/wp-content/uploads/2019/12/Radar-F124.pdf.

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now have to be able to detect ballistic missiles,[110] to the procurement of new PAC-2 GEM-T missiles that are optimised for use against stealth aircraft or cruise missiles,[111] to new long-range sensors for the air defence frigates.[112] However, Germany does not plan to equip its current air defence frigates with exo-atmospheric ("upper layer") interceptors.[113]

To retain and improve its AMD capabilities, Germany is currently undertaking some important replacement and procurement programmes in the land and maritime domain.

In the latter, the Ministry of Defence (MoD) draws first plans for the successor of the aging F-124 Sachsen-class air defence frigates of the German Navy. Preliminary listed as the F-127 Next Generation Frigate, it is explicitly designed for high-intensity conflicts and with the deliberate goal to fulfil all endo-atmospheric missile defence tasks, including addressing hypersonic missiles. Germany currently plans to procure six F-127 frigates, which will eventually replace three F-124s.[114]

In the land domain, Germany is in the process of procuring new systems for both VSHORAD and medium-range air defence. While VSHORAD is obviously not relevant for missile defence tasks, it has been a neglected air defence capability since the out-phasing of the last German Self-Propelled Anti-Aircraft Guns (SPAAGs) in 2015. Besides the urgent requirement to equip the next German-led VJTF in 2023 with VSHORAD capabilities, Germany also explores the development of future systems to account for new threats such as small Unmanned Aerial Vehicles (UAVs). To this end, it launched a project with several partial stages. The first tender is currently scheduled for 2022, followed by a second one (undated) and the final third one in 2026. Hence, these might result in increasing VSHORAD capabilities for the *Bundeswehr* during the 2020s – funding provided.

More important for the subject at hand is the TLVS procurement, for which the MoD and its procurement agency – the *Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr* (BAAINBw) – have received the final offer in August 2020 by the sole bidder consortium of Lockheed Martin/MDBA Germany, which pitched the MEADS programme.[115] The *Bundeswehr* intents TLVS as the replacement for the Patriot as the German medium-range AMD system. It shall also include a short-range effector from a German supplier, Diehl's IRIS-T SL. The

[110] Waldemar Geiger, "Bundeswehr Writes Air Surveillance Radars from with BMD Capability", in *Europäischer Sicherheit & Technik*, 26 March 2020, https://esut.de/?p=19577.

[111] Gerhard Heiming, "One Billion Euros for Procurement", in *Europäische Sicherheit & Technik*, 3 July 2020, https://esut.de/?p=21540.

[112] "New Long-Range Radar F124 - Receivables, Timing and Prospects", in *Europäische Sicherheit & Technik*, 8 May 2019, https://esut.de/?p=12325.

[113] German Parliament, *Drucksache 18/9265*, cit., p. 4.

[114] Andreas Uhl, "The Next Generation of Air Defense", cit.

[115] Dorothee Frank, "Updated Offer for TLVS Submitted", in *Europäische Sicherheit & Technik*, 14 August 2020, https://esut.de/?p=22243.

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procurement process has seen several hick-ups over the years. From an originally tri-lateral project between Germany, the US and Italy, only Germany continues to support the development of MEADS and wants to procure it. Within the German procurement process, the bidder consortium had to deliver three offers as the procurement agencies found insufficiencies in the first two, based on German procurement rules. In particular, the consortium had to rework their information and intentions regarding the integration of the PAC-3 MSE effector into the system. This rework of the offer delayed the programme by another year.[116] Yet, so far, the procurement is not financially secured in the current draft of the Defence Ministries' budget.[117]

As of now, the whole TLVS programme would procure eight fire control radars, three long-range sensors, four mid-range sensors, 15 launchers for Patriot PAC-3 MSE missiles as well as 17 launchers for the IRIS-T SL. At least according to the MoD, this package will "significantly exceed the protection performance currently achieved with Patriot".[118] The MoD expects IOC for 2027 and a service life of at least 30 years.[119] It seems to be an odd choice for Germany, which focuses on cooperation with its allies so much, to buy a different system than its partners overwhelmingly selecting Patriot.[120] However, proponents argue that the open-system architecture of MEADS – if it is chosen – will provide seamless integration with the Patriot systems. Another argument in favour of the MEADS is the technological ownership that comes with it and the industrial production: MEADS is a co-production by German (MBDA Germany), US (Lockheed Martin) and Italian (MBDA Italia) companies.

Lastly, Germany is in the process of building up a space-based early warning and target designation system for missile defence.[121] Such a system would constitute a first for the *Bundeswehr* in terms of space-based early warning systems. The *Bundeswehr* plans to iterate on the system so that it can provide a key component of a national BMD capability (including against hypersonic vehicles) in the future. However, the project only started in May 2019 and is still in its early beginnings. Furthermore, Germany joined the TWISTER PeSCo project[122] in the autumn of

[116] Federal Ministry of Defence, *11. Bericht des Bundesministeriums der Verteidigung zu Rüstungsangelegenheiten*, Vol, 1, Berlin, June 2020, p. 107, https://www.bmvg.de/resource/blob/263830/274c9b18032991fe3233bf1770ce22a5/200200609-download-11-bericht-des-bmvg-zu-ruestungsangelegenheiten-data.pdf.

[117] Donata Riedel, "Die Bundesregierung verspricht der Bundeswehr neue Waffen – doch es fehlt das Geld", in *Handelsblatt*, 9 November 2020, https://www.handelsblatt.com/26605474.html.

[118] German Parliament, *Drucksache 19/12983 – Rüstungspolitische Sachstandsermittlung zum Taktischen Luftverteidigungs-systems*, 4 September 2019, p. 5, https://dipbt.bundestag.de/doc/btd/19/129/1912983.pdf.

[119] Ibid, p. 6.

[120] E.g. Sweden, Poland, Romania.

[121] Federal Ministry of Defence, *11. Bericht des Bundesministeriums der Verteidigung zu Rüstungsangelegenheiten*, cit., p. 34.

[122] PeSCo website: *Timely Warning and Interception with Space-Based Theater Surveillance (TWISTER)*, cit.

2020.

Table 1 | German AMD capabilities per domain (2019)

	Year 2019	Near-to-mid-term future (~ 2025-2035)
Land	• 30 Patriot PAC-2/PAC-3 (medium-to-long-range) • 20 Ozelot (VSHORAD) • Stinger MANPADS (VSHORAD) • 12 MANTIS (C-RAM)	• TLVS • New VSHORAD system
Sea	• M3 Sachsen (F-124), 4 8-cell Mk 41 Vertical Launch Systems with Standard Missile-2 (SM-2) Block IIIA SAM/RIM-162B ESSM SAM	• up to 6 Next Generation Frigate (F-127)
Space		• Space-based early warning and target designation system for missile defence

Source: IISS, *Military Balance 2020*; author's compilation.

6.3 Technological and industrial rationale

Today, Germany shows a technological and industrial profile related to AMD that is specialised in some specific areas and technologies. Consequently, Berlin is industrially dependent on foreign suppliers. This is also reflected in Germany's current defence industrial Strategy Paper, which lists AMD as technologies that can be acquired from European or global partners and are thus not seen as a key technological area.[123] However, parts of sophisticated AMD systems, such as the sensors and technologies related to network-enabled operations/cryptography are defined as key ones. Therefore, the MoD and the BAAINBw shall prioritise domestic suppliers for these technology areas, but not other components of AMD such as effectors.

MBDA Germany, Diehl, Hensoldt and Rheinmetall are the companies that constitute the German defence industrial backbone active in the fields of military electronics and air defence equipment.

Even though Germany was and continues to be active in the development of AMD capabilities, it still has significant industrial dependencies, primarily towards the US. While some components in imported systems came or come from Germany,

[123] Federal Government, *Strategy Paper of the Federal Government on Strengthening the Security and Defence Industry*, February 2020, p. 3, https://www.bmwi.de/Redaktion/DE/Downloads/S-T/strategiepapier-staerkung-sicherits-und-verteidigungsindustrie-en.pdf.

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these are either technologically rather simple hardware such as trucks or constitute some parts of the electronic systems. Historically, German forces bought all their medium-to-long-range AMD systems and especially the effectors from the US (Nike, Hawk, Patriot, effectors on ships like the Standard Missile-2 - SM-2). Indigenous industrial capabilities focused very much on VSHORAD and air defence guns. This is signified in Rheinmetall, the main gun producer in Germany, which also incorporated other European companies in this sector, first and foremost the Swiss Oerlikon in 1999.

Being the most important ongoing procurement programme, TLVS both fits this picture while it also presents some new developments. Its components are showing its heritage as an originally trilateral cooperation between Germany, Italy, and the US with a consortium between MBDA Germany and Lockheed Martin now offering the system to the *Bundeswehr*. While Lockheed Martin is responsible for the surveillance radar, Selex Sistemi Integrati (now part of Leonardo) and MBDA Italia provide the fire control radar. The German Hensoldt is responsible for the radar's transmit/receive modules.[124] For short-to-medium-ranges, MEADS will use the IRIS-T SL effector provided by Diehl. This marks a novelty and is largely attributable to the fact that the IRIS-T SL is derived from the air-launched IRIS-T,[125] representing an industrial area where the German company Diehl is traditionally strong. For medium-to-long-range engagements, MEADS will use Lockheed Martin's Patriot PAC-3 MSE effector, continuing the German reliance on US effectors in that segment. The effector used on the F127 future air defence frigates is still unknown as the analysis of available American and European systems is still ongoing.[126]

Consequently, defence industrial dependencies will continue in the foreseeable future in areas like medium-to-long-range effectors. However, German companies will be able to provide components and subsystems, from sensitive equipment like sensors to radars to rather unsophisticated hardware such as trucks and generators.

[124] Army Technology website: *Medium Extended Air Defence System (MEADS)*, https://www.army-technology.com/projects/meads.

[125] Diehl Defence website: *IRIS-T SL*, https://www.diehl.com/defence/en/products/guided-missiles/#iris-t-sl.

[126] Andreas Uhl, "The Next Generation of Air Defense", cit.

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7. Italy

by Alessandro Marrone and Karolina Muti

7.1 Strategic and military dimension

History and geography show that Italy is exposed to missile threats from its unstable Southern and Eastern neighbourhoods. In 1986, the Italian territory was subject to a missile attack, with two SS-1 Scud launched by Libya and fallen just a few km away from the island of Lampedusa – where a small US military installation[127] was located at that time. In the 1990s, the Adriatic coastline was at risk of Serbian missile attacks[128] while Rome was providing a significant contribution to NATO operations, first in Bosnia Herzegovina against Serb militias, then directly in Kosovo and Serbia.[129] Since the 2000s, Italy, alongside with other Southern and South-Eastern NATO members, fell gradually within the reach of Iranian missiles. Today, the threat scenario has worsened and will become even more challenging with the introduction of new weapons, including hypersonic ones. Last but not least, Italy is one of the few European nations hosting US tactical nuclear weapons,[130] and this makes the country a possible target by default – alongside e.g. with Germany – of Russian potential missile attacks against American dual-capable bombers headquartered on Italian soil.

Despite these concerns, missile defence has not enjoyed a high priority at the politico-strategic level in Italy, particularly in the post-Cold War period, when a variety of political and cultural rationales brought attention to other aspects of defence policy. With regards to Italy's case, the low prioritisation is reflected in, and negatively impacts, the status of missile defence capabilities across the Italian Armed Forces. Procurement choices however should be made carefully, by taking into consideration all relevant factors, including their potential impact on the deteriorating security context.

The Air Operations Command (*Comando Operazioni Aeree* - COA) is tasked with assuring surveillance and defence of the national airspace. More precisely, the Integrated Air and Missile Defence (*Difesa Aerea Missilistica Integrata* - DAMI) unit, located in Poggio Renatico, controls the national airspace through a network of active and passive sensors, mainly radar systems.[131] Nevertheless, particularly

[127] The installation included Long Range Navigation (LORAN) systems.

[128] Roberto Bianchin and Vincenzo Nigro, "I missili serbi minaccia per l'Italia", in *La Repubblica*, 21 April 1993, https://ricerca.repubblica.it/repubblica/archivio/repubblica/1993/04/21/missili-serbi-minaccia-per-italia.html.

[129] See in this regard: Vincenzo Camporini et al., *The Role of Italian Fighter Aircraft in Crisis Management Operations: Trends and Needs*, Roma, Nuova Cultura, March 2014, https://www.iai.it/en/node/2155.

[130] Stefano Silvestri and Alessandro Marrone, "Italy", in Sophia Becker and Christian Mölling (eds), *(Nuclear) Sharing is Caring*, DGAP Report No. 10, June 2020, p. 9-10, https://dgap.org/en/node/33878.

[131] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio*

with respect to the Air Force – which has the institutional task of national airspace defence – there is a "gap" in missile defence capabilities, as stated also in recent MoD documents.[132]

The majority of Italy's missile defence systems is managed by the Army – such as the SAMP/T – or by the Navy – such as the short-range Surface Anti-Air Missile (SAAM), used for self-defence on board of Cavour flagship, the Principal Anti-Air Missile System (PAAMS) on the dedicated air defence Guided Missile Destroyers (DDGs) Orizzonte, and the Surface Anti Air Missile/Extended Self Defence (SAAM/ESD) on European Multi-Purpose Frigates (*Frégate Européenne Multi-Mission* - FREMM). In addition, the Air Force, which in the past operated also the long-range area Nike AMD system, has been using the Spada air defence system, armed with the Aspide missile since the 1980s, whereas the Italian Army is using the Skyguard Aspide missile. A promising system that is currently under development and could be accessed by all three services is the air defence missile Common Anti-air Modular Missile-Extended Range (CAMM-ER).

In this context, three major issues are worth mentioning. Firstly, at the moment, Italy as a whole does not have a credible and updated IAMD capability against current ballistic missiles, let aside upcoming hypersonic weapons. This situation is somehow similar to several other NATO members which rely on the Alliance's collective missile defence. However, other major European countries have invested in missile defence more than Italy, which now finds itself in a weak position even against short-range ballistic missiles, as stressed by the Italian Chief of Defence Gen. Enzo Vecciarelli during a hearing at the Parliament Defence Committee in November 2020.[133]

Secondly, IAMD is intrinsically joint (and combined) – as also stated in NATO documents[134] – yet in Italy the current integration at the joint level is not satisfactory, and its components are distributed among different services. Again, this situation is similar to what happens also to other European members of NATO. However, countries such as the UK and France have moved towards a more centralised approach by putting assets, including French SAMP/T batteries, under a single service chain of command. In contrast, in Italy the joint level of integration remains rather weak, and the attitude in favour of a distribution of responsibilities among the three Armed Forces is still prevailing. Such a fragmentation also applies

2020-2022 - 2020 Edition, October 2020, http://www.difesa.it/Content/Documents/DPP/DPP%20 2020-2022.pdf.

132 Ibid., p. 38.

133 Italian Chamber of Deputies, "Covid e attività Forze armate, audizione generale Vecciarelli" [video], in *WebTV*, 3 November 2020, https://webtv.camera.it/evento/17015.

134 G.W. 'Berry' Pronk, "The Importance of Integrated Air and Missile Defence Training", in *JAPCC Journal*, No. 30 (Spring/Summer 2020), p. 78-84, https://www.japcc.org/the-importance-of-iamd-training. The source cites: "Air defence is an essential part of 'Air Power'. Air Power in NATO is managed by NATO AIRCOM. IAMD, however, is a joint operation, and so includes assets of the Land and Maritime Command as well." Ibid., p. 82.

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to other military capabilities. Yet, that is particularly worrying in the IAMD field, as the current situation makes the chain of command and the subsequent military response more complex while, by definition, a missile defence architecture should be steadfast and extremely timely in order to intercept a threat as far as possible from national territory and/or forces.

Thirdly, while IAMD primarily regards the surveillance and protection of the Italian soil, it should be mentioned that Italy is significantly engaged in military operations abroad, as well as in civilian missions in conflict zones, and it is one of the largest contributors in terms of personnel to NATO, EU and United Nations efforts. As of 2020, Rome is the largest contributor to the Alliance's operations after the US, and holds the command of operations of NATO's Kosovo Force (KFOR) in Kosovo, the EU's Operation IRINI in the Mediterranean Sea, and the United Nations Interim Force in Lebanon (UNIFIL) – while maintaining a robust military presence in Afghanistan. Italy has also deployed a national mission in Libya and participates in the US-led coalition operating in Iraq – both theatres are highly subject to missile threats as epitomised by Iranian attacks in 2020 against Iraqi bases hosting also Italian troops.[135] This results in a high demand and political value of theatre force protection, which includes tactical AMD. For instance, a SAMP/T battery has been deployed in Kuwait for the protection of Italian forces operating in Iraq within the global coalition against so-called Islamic State of Iraq and Syria (ISIS), in the context of *Operazione Prima Parthica*.[136] Moreover, Italy has actively contributed to NATO's IAMD by deploying a SAMP/T battery and 130 personnel to operate the system next to the border between Turkey and Syria in the framework of NATO Active Fence Operation (*Operazione Sagitta*).[137] Such deployment followed Ankara's request to the Alliance to help protect its territory from air and missile attacks coming from Syria and, within the rotation among NATO members, Italy's support to Turkey lasted from January 2018 to the end of 2019.

These military commitments abroad are one of the main reasons why efforts have been undertaken or are planned for the development of the lower layer of IAMD, considering that in new scenarios air dominance will be far from granted, with a growing need for fixed and mobile air defence capabilities. The upper layer enjoys much less priority. However, the threat in this area is increasing and changing fast from a geopolitical, military and technological point of view, also due to the development of hypersonic weapons. Therefore, Italian IAMD risks remaining particularly weak, while the missile threats are likely to increase further in the next future.

[135] On the growing risks faced by Italian Armed Forces in operations abroad, see: Alessandro Marrone, "Italian Military Operations: Coping with Rising Threats and Declining US Leadership", in *IAI Commentaries*, No. 20|15 (March 2020), https://www.iai.it/en/node/11439.

[136] Stefano Pioppi, "L'Italia a Difesa della stabilità in Medio Oriente. La visita di Guerini in Iraq", in *Formiche.net*, 29 September 2020, https://formiche.net/?p=1311180.

[137] Italian Ministry of Defence website: *Turchia - Operazione "Active Fence": Contributo Nazionale*, https://www.difesa.it/OperazioniMilitari/op_intern_corso/NATO_ActiveFence/Pagine/ContributoNazionale.aspx.

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Against this backdrop, the latest Multi-Year Planning Document (*Documento Programmatico Pluriennale* - DPP) – the document issued in October 2020 by the Italian MoD to define its budget priorities until 2022 – does list a "missile defence capability able of responding to ballistic and hypersonic threats", coupled with the "development of a multilayered air defence concept", and the "acquisition of a BMD radar (Upper Layer Long Range)" among the "additional" priorities, although these capabilities do not have a dedicated budget at the moment.[138]

In his 2019 Strategic Concept, Gen. Vecciarelli emphasised how non-NATO countries are developing Anti-Access/Area Denial (A2/AD) capabilities similar to the Alliance's ones, and how even non-state actors' missile capabilities have become particularly alarming.[139] Such developments have a considerable effect on European security and worsen international dialogue and cooperation leading, for instance, to the termination of the INF Treaty and raising new questions about the evolution of the European security context.

According to Gen. Vecciarelli, Italian Armed Forces need to develop air defence capabilities, both ground- and sea-based, which could then become part of NATO's IAMD.[140] Italian Armed Forces should develop a surveillance, tracking and engagement capability for the Lower Layer, as well as a surveillance capability for their Upper Layer, and such developments would represent a concrete contribution to the transatlantic IAMD.

7.2 Capabilities

As mentioned before, Italian missile defence capabilities are distributed among the three services and procured through a number of specific programmes. The most important AMD systems owned by Italy, notably pertaining to the Family of Systems Surface-Air Future (FSAF), have been developed through cooperative programmes together with France: SAMP/T, SAAM and PAAMS belong to this category, and are analysed in the next paragraphs. The development of PAAMS has also involved the UK.

SAMP/T

SAMP/T is a state of the art, short-to-medium-range surface-to-air missile defence system, developed through a collaboration between Italy and France via the

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[138] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2020-2022*, cit., p. 75, 77.

[139] Italian Ministry of Defence, *Il Concetto Strategico del Capo di Stato Maggiore della Difesa. Introduzione*, https://www.difesa.it/SMD_/CaSMD/concetto_strategico_casmd/Pagine/1_Introduzione.aspx.

[140] Italian Ministry of Defence, *Il Concetto Strategico del Capo di Stato Maggiore della Difesa. Le Componenti*, https://www.difesa.it/SMD_/CaSMD/concetto_strategico_casmd/Pagine/6_2_Componenti.aspx.

Eurosam consortium with the aim to replace the Hawk missile system.[141] Eurosam is composed by MBDA France, MBDA Italia and Thales, and has been working on SAMP/T through an Organisation for Joint Armament Cooperation (*Organisation Conjointe de Coopération en matière d'Armement* - OCCAR) programme. According to the Italian Army, SAMP/T has a high tactical and strategic mobility, being easily deployable by air, sea and land.[142] Official documents underline how SAMP/T is among the Army's weapon systems with the highest average efficiency, reaching 90 per cent.[143]

SAMP/T serves as air and defence missile defence for area and forces protection, and contributes to IAMD.[144] Indeed, thanks to the Aster-30 B1 effectors with a range of 60-to-80 km, it is the only missile defence system in Italy which might be considered capable of providing some degree of limited BMD, and can also provide limited early warning.[145] It is worth noting that the effectors are produced in France.[146] Moreover, even if the first part of the programme was developed jointly, Italy and France have then developed different subsystems according to specific national requirements.[147]

The addition of Aster 30 B1 NT missiles and the next evolution of the system – SAMP/T New Generation (NG) – increases the BMD ability of the system, particularly in intercepting short- and some medium-range ballistic missiles to be engaged in the endo-atmosphere. Over the last few years, Italy and France have been working on the convergence of operational requirements for SAMP/T NG.[148] The current SAMP/T does feature a radar made in France. The SAMP/T NG will feature a radar from Leonardo's Kronos family, developed thanks to the technology funded by the 2015 *Legge Navale* (Naval Law) and transferred to the land domain, representing a positive example of cross domain technology exploitation.

SAAM and its ESD version

Similarly to the SAMP/T, the Surface Anti-Air Missile-IT (SAAM-IT) was developed in the framework of Eurosam. SAAM-IT is composed by a Vertical Launching System (VLS) Sylver A43, and Aster 15 N missiles. In the Italian version of the system, an Agis C2 system is integrated with a multifunctional passive phased array radar

[141] Italian Army website: *Il sistema d'arma SAMP/T*, http://www.esercito.difesa.it/equipaggiamenti/Artiglieria/Artiglieria-Controaerei/Pagine/SAMP-T.aspx.

[142] Ibid.

[143] Italian Army, *Rapporto Esercito 2019*, February 2020, p.71, http://www.esercito.difesa.it/Rapporto-Esercito/Pagine/default.aspx.

[144] Ibid.

[145] Michele Nones, Paola Sartori and Andrea Aversano Stabile, "La difesa missilistica e l'Italia", cit.

[146] Interview, 29 July 2020.

[147] Ibid.

[148] Luca Peruzzi, "MBDA e i programmi che coinvolgono l'Italia", in *Analisi Difesa*, 24 March 2019, https://www.analisidifesa.it/?p=123220.

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developed by Leonardo, the EMPAR.[149] The SAAM-IT guarantees the self-defence of the Italian Navy aircraft carrier Cavour,[150] and reaches aircraft targets up to 30 km and missile targets up to 15 km.[151]

The updated version of the system, the SAAM/ESD, has been developed by MBDA Italia and provides for the self-defence of the FREMM frigates.[152] It includes a C2 system with a Sylver A50 VLS developed by DCNS, for both Aster 15 and 30 missiles, and it is integrated with the multifunctional 3D radar with Active Electronically Scanned Array (AESA) Grand Kronos Naval, developed by Leonardo.[153]

PAAMS

The PAAMS programme stems from the cooperation between Italy, the UK and France, and is a "surface-to-air anti-missile [system] for self-defence, consort protection and area defence."[154] In the case of Italy, the programme is part of an effort to modernise ground- and sea-based defence systems, as well as to substitute obsolete systems that use Aspide effector.[155] The PAAMS is a medium-range system able to target aircraft up to 120 km and missiles up to 25 km.[156] Apart from the protection of the warship hosting the system, the PAAMS serves to provide naval area defence to nearby ships.[157] The system is installed on the frigates Orizzonte. OCCAR coordinates the programme and manages the ammunition procurement for the land and maritime systems on behalf of the involved states, in order to achieve greater economies of scale.[158] The VLS can accommodate both Aster 15 and Aster 30, eight in each module. The Italian and French versions differ from the British one regarding the type of radars.

As stated in the DPP 2020-2022, a modernisation of PAAMS is currently ongoing, and it is aimed at increasing the systems' anti-ballistic capability through the integration of a new effector called Block 1 Nouvelle Tecnologie (B-1 NT), a precision guided missile capable of intercepting ballistic targets,[159] a new AESA radar from Leonardo's Kronos family, and an updated C2. The budget for this

149 "Testato il SAAM/IT sulla Cavour", in *DifesaNews*, 26 May 2011, http://www.difesanews.it/?p=4364.

150 OCCAR website: *FSAF – PAAMS*, http://www.occar.int/programmes/fsaf.

151 Eurosam website: *Naval Systems*, https://www.eurosam.com/products/naval-systems.

152 Luca Peruzzi, "Qualificato il sistema missilistico imbarcato MBDA Italia SAAM-EDS", in *Analisi Difesa*, 13 April 2017, https://www.analisidifesa.it/?p=106521.

153 Ibid.

154 Eurosam website: *Naval Systems*, cit.

155 Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2020-2022*, cit.

156 Eurosam website: *Naval Systems*, cit.

157 OCCAR website: *FSAF – PAAMS*, cit.

158 Ibid.

159 Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2020-2022*, cit.

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programme is provided by Italy's Ministry of Economic Development and amounts to approximately 1.2 billion euros to be allocated until 2029.[160] The MoD considers that such a modernised system will let the Italian Navy and Army effectively respond to certain threats until 2035.

In addition to that, the defence budget planning for 2020-2022 allocates a first batch of funds for the mid-life update of a limited number of Navy's Aster 15 and 30 missiles, allocating 18 million euros in three years.[161] Such activity will bridge the gap until the launch of a larger refitting plan, scheduled for 2023, designed for all the Aster interceptors of both the Navy and the Army.

Naval-based BMD development has continued with the FREMM missiles system, again with different requirements between France and Italy, and is planned to move forward to equip the new warships to be financed by the 2015 naval programme, defined by the so called *Legge Navale* until 2025. Namely, Kronos radars have experienced a radical advancement with AESA technologies and multifunction capacity, and they are currently able to manage both air surveillance and fire control. They did benefit from Navy studies on BMD and, thanks to the *Legge Navale* funding, will be embarked on the new Landing Helicopter Dock (LHD) ship. Such state of the art, namely the use of and advancements in digital and long-range radars, paves the way for similar technological developments in the land domain.

CAMM-ER

The CAMM-ER is a missile developed in cooperation by MBDA Italia and MBDA UK, with the purpose of replacing the old Spada and Skyguard air defence systems in Italy, which are using Aspide missiles. In 2021, the latter will come to the end of its operational life after almost 40 years of service. The CAMM-ER interceptor will reach supersonic speed, and should be deployable also in an environments with heavy electromagnetic interferences.[162] The CAMM-ER should provide the Army and the Air Force with a modern short-to-medium-range missile defence, somehow complementary to the BMD component – and not replacing it – within the broader IAMD. The CAMM-ER contract for the development phase was signed at the end of 2019, after some delays in the government decision.

Finally, it should be considered that the Italian air defence network of long-range radars, including RAT 31, would play a role in the detection of ballistic missiles targeting Italy.

[160] Ibid., p. 101.

[161] Ibid.

[162] Italian Army Staff, *Nuove tecnologie per l'Esercito italiano*, 13 January 2020, http://www.esercito.difesa.it/comunicazione/Pagine/Nuove-tecnologie-per-l-Esercito-Italiano20200113.aspx.

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7.3 Industrial and technological dimension

The Italian industrial and technological landscape sees the presence of two main actors in the missile systems domain, Leonardo and MBDA Italia. The former is Italy's largest company in the aerospace and defence sector. In particular, its Electronics Division encompasses a broad portfolio of technologies and systems provided by four business units, for a total of approximately 12.000 employees distributed in nine Italian regions, as well as in the US and the UK. Among the aforementioned technologies, particularly relevant for IAMD are radars and Command, Control, Communication, Computer and Intelligence (C4I) systems. In particular, they include low level radar systems to counteract low flying high manoeuvring threats, and multi-mission fully digital sensors belonging to Kronos radar family against ballistic missiles.[163] This sensor suite covers both air and missile threats, and exerts fire control on Aster missile and cannons. Indeed, they are integrated within a multi-layered system of systems, enabling monitoring, information sharing and interception.[164] The AESA Kronos radars, as well as C2, communications and combat management systems, have been tested by the Italian Navy through the participation in the Formidable Shield exercise led by the US in the North Atlantic Ocean on September 2015, 2017 and 2019.[165] Regarding C2, Leonardo is investing in new algorithms to detect ballistic missiles trajectories by leveraging Machine Learning (ML) to shorten the time to provide relevant inputs to decision-makers, sensors and effectors.[166] Investments are also made in AI to support decision-making, while always keeping the human in the loop.[167] Finally, when it comes to naval-based missile defence capabilities, Leonardo is responsible for the Combat Management System (CMS) operating all sensors and weapon systems including missiles.

MBDA Italia is part of MBDA Missile Systems, the European leader in the missile sector whose shares are divided among Airbus (37.5 per cent), BAE Systems (37.5 per cent) and Leonardo (25 per cent). The multinational group counts on over 10,000 employees in Europe, including about 1,300 in Italy, where the site in Fusaro has a particular relevance. Its 60 products encompass missiles and launchers, missiles'

[163] Aiad website: *Leonardo Società per azioni*, https://aiad.it/?p=34502&lang=en.

[164] Leonardo, *Multi-domain Integrated Air and Missile Defence*, 2017, https://www.leonardocompany.com/documents/20142/119136/body_Land_Naval_Integrated_Air_and_Missile_Defence_LQ_Pages_mm08843_.pdf.

[165] Luca Peruzzi, "Leonardo e Marina Militare testano le capacità contro i missili balistici", in *Analisi Difesa*, 6 September 2019, https://www.analisidifesa.it/?p=127262. The exercise is specifically aimed at testing the full interoperability of participating Navies in the area of Maritime IAMD in an extremely realistic scenario where a large number of missile threats (both air breathing and ballistic) have been included. FS 21 will be a new opportunity for the Navy and industries to further test new technologies, systems – already existing and under development – as well as to validate standards, train operators, crew and staff personnel in practicing IAMD/BMD tactics, techniques and procedures.

[166] Interview, 3 December 2020.

[167] Ibid.

engines, components, fire control systems and guidance systems.[168] Noticeably, MBDA Italia maintains the design authority over a complete missile defence capability, acting as system integrator for the Armed Forces which, as a result, are enabled to maintain full operational sovereignty on the acquired capabilities. Looking at specific systems, the C2 encompasses Threat Evaluation and Weapon Assignment (TEWA) as well as engagement planning, leveraging components either produced in house or acquired by other companies – i.e. the Leonardo radars – as happens on Cavour and FREMM ships.[169] Concerning effectors, MBDA Italia holds the design authority on the seeker and, thanks to the experience on Aspide and the cooperation with French partners on Aster, it is currently able to act as system integrator on CAMM-ER.[170]

Both MBDA Italia and Leonardo and have been heavily involved in all the aforementioned programmes. Moreover, both companies are investing in missile defence related technologies, such as AESA radars, for which they have reached a cooperation agreement.[171]

Against this backdrop, the space sector is increasingly important in relation with BMD. During the Cold War, only world superpowers were able to develop and produce space-based early warning systems, linked to their nuclear deterrence. Indeed, their costs made these systems not affordable for European countries. Then, recent breakthroughs in terms of performance, automation, launching capacity, as well as reduction of size, weight and costs of space assets, have made it more affordable to use satellites for missile defence. Moreover, it has become easier to launch and manage a constellation of satellites and mini satellites. The latter have created a market for small launchers, thus reducing the access barriers for several nations, which are now able to autonomously launch their space assets. At the same time, the aforementioned growth of missile threats made the space dimension more relevant for IAMD. Indeed, constellations of satellites will be more and more needed to: (i) detect missiles since their launch, mainly through thermal infrared sensors; (ii) enable fast and secure communication through the nodes of the missile defence architecture, also thanks to cryptography; (iii) contribute to counter measures, including but not limited to electronic warfare. Space assets have also significant capacities to process data and enable C2, with a view to quantum computing, and which could be useful for missile defence. In this regards, two important players operate in Italy thanks to the Space Alliance between Thales and Leonardo. The first is Thales Alenia Space, whose shares belong 66.6 per cent to the French company and 33.3 per cent to the Italian one, which develops and produces satellites for communication, Position Navigation and Timing (PNT), Earth Observation (EO) and space exploration. The second one is Telespazio, owned again by Thales (33.3 per cent) and Leonardo (66.6 per cent), which manages satellites control and space

[168] Aiad website: *MBDA Italia S.p.A.*, https://aiad.it/?p=34597&lang=en.
[169] Interview, 9 December 2020.
[170] Ibid.
[171] Luca Peruzzi, "MBDA e i programmi che coinvolgono l'Italia", cit.

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services. Over the last two decades, Italy's space industrial capacities have steadily grown thanks to specific programmes funded by the Italian Space Agency and the MoD, as well as because of the participation in major European projects such as Galileo (on PNT), Copernicus (on EO), and Governmental Satellite Communication (GovSatCom) – which, in turn, are strongly supported by Italy, Rome being the third contributor to the European Space Agency (ESA). More progresses are expected due to the growing importance of government satellite communication and tracking of space debris. This will result in high-level technological know-how available for further initiatives on missile defence.

7.4 The Euro-Atlantic dimension

The NATO framework

The objective to develop C2, sensors and missile defence systems to be integrated in the Alliance's IAMD is a traditional Italian standpoint, which has also been restated in the last DPP 2020-2022. Indeed, Italy is well aware that only a NATO C2 architecture federating a variety of sensors, radars and effectors provided by Allies can ensure the IAMD of the European continent, including the Italian territory, in an effective and sustainable way.

In this context, over the last years NATO has been developing a new C2 architecture for Europe, and Italy is among the first European members to host a component of such architecture as validating nation, at the Poggio Renatico command.[172] Namely, the NATO Deployable Air Command and Control Centre (DACC) is co-located there with the Italian Air Force's Air Operations Command. The DACC offers C2 operational capacities within the NATO ACCS programme, including a specific radar unit declared "mission capable" for ACCS – the first one in Europe. The C2 is currently able to manage protection against the lower layer of missile threats, and aims to address the upper layer in the next future.

Moreover, in October 2020, the Defence Ministers of ten European NATO countries,[173] including Italy, signed a Letter of Intent (LoI) launching a multinational initiative for developing very short-range, short-range and medium-range Ground Based Air Defence (GBAD) capabilities. The aim is to deliver an innovative solution against a full range of air and missile threats, by implementing a systematic modular approach able to equip participating Allies with versatile, scalable solutions, allowing them to create threat-tailored GBAD force packages.[174] These solutions will have to cover the entire very short-to-medium-range spectrum, while it remains unclear what impact they will have on the long-range missile

[172] Interview, 29 July 2020.

[173] Belgium, Denmark, Germany, Hungary, Italy, Latvia, the Netherlands, Slovenia, Spain and the UK.

[174] NATO, *Ten Allies Agree to Explore Modular Solution for Ground Based Air Defence*, 23 October 2020, https://www.nato.int/cps/en/natohq/news_178950.htm.

threats.

The EU PeSCo project TWISTER

The majority of Italy's current missile defence systems were developed by relying on intergovernmental cooperative programmes, especially with France and/or the UK, often managed by OCCAR. It is the case of SAMP/T, SAAM-IT, PAAMS and CAMM-ER programmes. Once PeSCo was established in 2017, it provided an opportunity to cooperate on missile defence also in the EU framework, and Italy has been very keen to commit on PeSCo cooperative projects[175] – also with a view to EDF co-funding.[176]

In this context, the TWISTER PeSCo project, participated by Italy together with Germany, Spain, Finland, and the Netherlands, can play an important role. As mentioned in previous sections, TWISTER is coordinated by France and aims to provide enhanced space-based early warning as well as endo-atmospheric interceptors designed by MBDA.[177] Italy and France have extensive experience in working together in the missile defence sector, and the involvement of EU major defence stakeholders could make the programme strategically relevant for Europe, provided that national protectionist logics do not prevail. Should the initiative succeed, the system would enter into service in 2030. TWISTER could and should also benefit from the EDF co-funding,[178] and would definitively contribute to NATO's BMD.[179] The project could be synergic with other projects co-funded by the EU, whether through the EDIDP and/or the EDF, focusing on satellites to fill a European gap on space-based early warning systems able to detect the launch of ballistic missiles.

However, TWISTER is not mentioned in the Italian DPP 2020-2022. This may be due to the early stage of the project, in which France has to provide a roadmap for its future development. Moreover, while the previous DPP 2019-2021 referred to the development of a "European" integrated missile defence system against the ballistic and hypersonic threat, in this year's document the word "European" has disappeared.[180] Generally speaking, the DPP 2020-2022 reserves limited funding to

[175] Alessandro Marrone, "PeSCo - The Italian Perspective", in *ARES Group Policy Papers*, No. 30 (September 2018), http://www.iris-france.org/notes/pesco-the-italian-perspective.

[176] Alessandro Marrone, "National Expectations Regarding the European Defence Fund: The Italian Perspective", in *ARES Group Comments*, No. 42 (October 2019), https://www.iris-france.org/notes/national-expectations-regarding-the-european-defence-fund-the-italian-perspective.

[177] PeSCo website: *Timely Warning and Interception with Space-Based Theater Surveillance (TWISTER)*, cit.

[178] "MBDA nel progetto missilistico europeo TWISTER", in *Analisi Difesa*, 16 November 2019, https://www.analisidifesa.it/?p=129288.

[179] PeSCo website: *Timely Warning and Interception with Space-Based Theater Surveillance (TWISTER)*, cit.

[180] Italian Ministry of Defence, *Documento programmatico pluriennale della Difesa per il triennio 2020-2022*, cit., p. 75.

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both PeSCo and EDF projects to be participated by Italy.[181] Yet, the state budgetary law envisages for 2021 a robust increase of defence budget with a focus on investments on equipment,[182] which may enable Italy to invest more in European cooperative initiatives.

The cooperation on European Air and Ballistic Missile Defence Interceptor (EABMDI)

Italy has acquired a certain know how on relevant BMD capabilities from its participation to the EABMDI programme.[183] The later primarily represented MBDA's answer to the requirements laid out by the European Defence Agency (EDA)'s Capability Development Plan (CDP), within the section of the CDP dedicated to Air Superiority priority, concerning short-to-medium-range missile threats.[184] Despite its embryonic nature, according to some experts it may pave the way for a future multinational programme aimed at enhancing European defence against long-range missiles, covering up to supersonic missiles and hypersonic glide vehicles.[185] According to the CDP perspective, this effort would be part of a broader approach aimed at integrating a variety of European air combat systems to guarantee air superiority.

181 Ottavia Credi and Alessandro Marrone, "La Difesa riporta l'attenzione sugli investimenti", in *AffarInternazionali*, 30 October 2020, https://www.affarinternazionali.it/?p=85076.

182 Pietro Batacchi, "L'Italia aumenta le spese militari per il 2021", in *Portale Difesa*, 14 December 2020. https://www.portaledifesa.it/index~phppag,3_id,3921.html.

183 Interview, 9 July 2020.

184 Michele Nones, Paola Sartori and Andrea Aversano Stabile, "La difesa missilistica e l'Italia", cit.

185 Ibid.

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8. Poland

by Karolina Muti

8.1 Strategic and military dimension

The National Security Strategy of the Republic of Poland issued on May 2020 states that, in the context of "strengthening operational capabilities of the Polish Armed Forces to deter and defend against security threats", the military should "ensure the state's capability for effective air defence, including missile defence", and build operational capabilities to "carry out precision long-range strikes as well as capabilities for anti-aircraft".[186] The Strategy indicates Russia's "neo-imperial policy" as "the most serious threat" to Poland's security.[187]

The geopolitical position of Poland, confining at East with Belarus, Ukraine, and Russia's territory of Kaliningrad, makes it particularly exposed to traditional security threats in comparison with its NATO Allies, especially considering recent modernisation and enhancement of the equipment deployed in the Russian exclave between Polish and Lithuanian territories. In 2017-2018, the 152nd Missile Brigade (*Chernyakhovsk*) based in Kaliningrad Oblast was equipped with new infrastructures to support the SS-26 Iskander missile systems,[188] a short-range ballistic missile capable of carrying both nuclear and conventional weapons and hit targets at a range of 400-500 kilometres (km), with a Circular Error Probable (CEP) of 2-to-5 meters (m). The 25th Coastal Missile Regiment (*Donskoye*) was equipped with Bal and Bastion systems while, in mid-2019, a reconstruction of the ammunition storage facility (including nuclear weapons) was completed.[189] The likely adoption of an A2/AD strategy by the Russian Federation in the event of conflict, supported by the deployment of A2/AD systems, makes the Eastern part of the Polish territory confining with Lithuania, named the Suwałki Gap,[190] particularly vulnerable to military attacks coming from the East.

Technical modernisation is a key objective for the MoD and Polish Armed Forces, and AMD is a priority.[191] Currently, Polish AMD weapon systems are Soviet-era equipment, which is obsolete and inadequate to meet contemporary challenges.

[186] National Security Bureau, *National Security Strategy of the Republic of Poland*, 12 May 2020, p. 18-19, https://en.bbn.gov.pl/en/publications/publications/769,National-Security-Strategy-of-the-Republic-of-Poland.html.

[187] Ibid., p. 6.

[188] Maria Domańska et al., "Fortress Kaliningrad. Ever Closer to Moscow", in *OSW Reports*, October 2019, https://www.osw.waw.pl/en/publikacje/osw-report/2019-11-07/fortress-kaliningrad.

[189] Ibid.

[190] A 40 miles-wide stretch of border between Poland and Lithuania, and the only land corridor through which NATO troops could pass to reinforce the Baltic states in the event of conflict.

[191] Marcin Terlikowski, "The Defence and Industrial Policy in Poland: Drivers and Influence", in *Ares Group Policy Papers*, No. 18 (July 2017), https://www.iris-france.org/notes/defence-and-industrial-policy-in-poland.

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Procurement and modernisation efforts of such systems imply a considerable investment in terms of resources, which needs to be continuative in the next years in order to be effective. The ambitious plan to spend 2.5 per cent of gross domestic product (GDP) in defence by 2030[192] is a commitment that could be put at risk by the budgetary implications of Covid-19, considering that some political parties are already asking for a re-allocation of resources from defence to the health sector and to other internal policies,[193] thus putting at risk some of the planned major programmes such as the Patriot system, F-35, etc.

Nevertheless, in 2020, the defence budget was expected to grow by 11 per cent, reaching 49,015 billion zloty (approximately 13.07 billion US dollars) – the equivalent of 2.1 per cent of GDP.[194] A considerable part of these resources, 3.51 billion US dollars, will be spent on modernisation, notably 763.5 million US dollars on AMD systems: continuation of Piorun and Poprad systems, as well as Wisła AMD system, and deliveries of the combined Pilica system. Furthermore, in January 2020, a 4.6 billion US dollars contract was signed for the acquisition of 32 F-35A[195] as part of the Harpia programme. Poland’s Minister of Defence Mariusz Błaszczak emphasised its interoperability with the Patriot system and with the fourth generation fighters F-16C/D. Additional expenditure will be dedicated to guided air-to-ground and short-range air-to-air missiles for F-16C/D, and to Spike Anti-Tank Guided Missiles (ATGMs) for Armored Personnel Carriers (APCs).[196] Following the Covid-19, the possibility of considerable cuts to the defence spending and further delays in procurement programmes has to be taken into consideration. In any case, territorial defence, with its AMD component, will stay high on the national agenda.

Poland perceives the possibility of a Russian aggression as an “existential” threat, putting in danger the very existence and territorial integrity of the country. From a missile defence perspective, Poland’s most challenging neighbour, Russia, has still the largest inventory of ballistic and cruise missiles, and its arsenal performs a wide variety of missions, from AD/A2 in local conflicts to delivery of strategic nuclear weapons across continents.[197] Moscow is very active in producing new variants of missiles with new capabilities, representing an additional worry for Warsaw. As a matter of fact, Russia is developing hypersonic glide vehicles, and very recently

[192] Maciej Szopa, “Poland Increases Defence Expenditure by over 11% in 2020”, in *Defence24*, 20 January 2020, https://www.defence24.com/poland-2020-defence-expenditure-almost-pln-50-billion.

[193] “Lewica chce cięć w budżecie wojska”, in *Defence24*, 25 September 2020, https://www.defence24.pl/lewica-chce-ciec-w-budzecie-wojska.

[194] Maciej Szopa, “Poland Increases Defence Expenditure by over 11% in 2020”, cit.

[195] Polish Ministry of Defence, *F-35 dla Polski*, 31 January 2020, https://www.gov.pl/web/obrona-narodowa/f-35-dla-polski.

[196] Maciej Szopa, “Poland Increases Defence Expenditure by over 11% in 2020”, cit.

[197] CSIS Missile Defense Project, “Missiles of Russia”, in *Missile Threat*, last modified 11 February 2021, https://missilethreat.csis.org/country/russia.

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test fired hypersonic missiles, SLBM,[198] and anti-satellite missiles.[199]

8.2 The Euro-Atlantic dimension

Aegis Ashore

Poland's geographical location, at the Eastern boarder of NATO and EU, makes it particularly challenging to defend its' territory from external threats. Warsaw represents the bulk of the so-called Eastern Flank of the Atlantic Alliance. Accordingly, Poland will host in the North-Western town of Redzikowo, near the city of Słupsk, part of the NATO BMD architecture,[200] which represents one of the two missions under NATO's IAMD,[201] together with Air Policing, and is currently under construction. NATO's BMD in Poland will be composed by the Aegis Ashore Missile Defence System (AAMDS), which is a land based weapon system, armed with exo-atmospheric missile defence interceptors – SM-3 Block IB and Block IIA – aimed at providing midcourse defence against short-to-intermediate-range ballistic missiles.[202] SM-3 use a hit-to-kill kinetic kill vehicle to intercept missiles and fire from Mk 41 VLS cells.[203] Block IIA interceptors differ from Block IB in rocket motors, which are larger, allowing it to defend broader areas, and in a larger kinetic kill system.[204] AAMDS is equipped with AN/SPY-1 S-band radars and is estimated to be operational in 2022.[205] The system completes Phase 3 of EPAA, which represents the US contribution to NATO's IAMD.

The Kremlin repeatedly defined the US system to be installed in Poland as a threat to Moscow, asking the US for legal reassurance on the fact that it will not be directed against Russia.[206] This kind of guarantee has never been formalised

[198] Masao Dahlgren, "Russia Test Fires Ballistic, Hypersonic Missiles", in *Missile Threat*, 14 December 2020, https://missilethreat.csis.org/russia-test-fires-ballistic-hypersonic-missiles.

[199] Masao Dahlgren, "Russia Tests Anti-satellite Missile", in *Missile Threat*, 16 December 2020, https://missilethreat.csis.org/russia-tests-anti-satellite-missile.

[200] NATO, *NATO Ballistic Missile Defence*, cit. The NATO Command Center for BMD is located in Ramstein (Germany), whereas another Aegis Ashore system is deployed in Deveselu (Romania).

[201] NATO, *NATO Integrated Air and Missile Defence*, cit.

[202] Ian Williams, "Aegis Ashore", in *Missile Threat*, last modified 15 June 2018, https://missilethreat.csis.org/defsys/aegis-ashore.

[203] CSIS Missile Project, "Standard Missile-3 (SM-3)", in *Missile Threat*, last modified 28 September 2018, https://missilethreat.csis.org/defsys/sm-3.

[204] Raytheon website: *SM-3 Interceptor*, https://www.raytheonmissilesanddefense.com/capabilities/products/sm3-interceptor.

[205] America's Navy, *Navy Commissions Naval Support Facility Redzikowo*, 3 September 2020, https://www.navy.mil/Press-Office/News-Stories/Article/2336225; Jen Judson, "Poland's Aegis Ashore Delayed to 2022 with New Way Forward Coming Soon", in *Defense News*, 18 February 2020, https://www.defensenews.com/smr/federal-budget/2020/02/18/polands-aegis-ashore-delayed-to-2022-with-new-way-forward-coming-soon.

[206] Katarzyna Czornik, "Tarcza antyrakietowa jako jeden z gwarantów bezpieczeństwa Polski", in Katarzyna Czornik and Miron Lakomy (eds), *Dylematy polityki bezpieczeństwa Polski na początku drugiej dekady XXI wieku*, Katowice, Wydawnictwo Regionalnego Ośrodka Debaty Międzynarodowej w Katowicach, 2014, p. 161-190, http://biblioteka.oapuw.pl/wp-content/uploads/2015/02/K.-Czornik-

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by Washington, which dealt with the issue by providing verbal reassurances,[207] considered by Moscow not enough to be credible. The widespread belief in Poland is that AAMDS will have a positive impact on Warsaw security. It is worth noting, however, that the AAMDS deployment influences significantly the geostrategic balance in Europe. Since Moscow interprets it as an anti-Russian move, the AAMDS has been one of the key causes of tension between NATO, the US and Russia,[208] and may contribute to a further militarisation of the region, and/or escalate military confrontation on the Eastern Flank. Additionally, the low point reached in relations with Russia resulting in a substantial lack of dialogue and in a confrontational dynamics across domains and regions in Europe, and its wider neighbourhood, coupled with Moscow's widespread use of a toolbox that includes a mix of military and non-military means – going beyond conventional conflict and towards a hybrid threat concept – complicates the security environment and makes it less predictable.

Looking for a special relationship with the US

Poland considers the strategic relationship with the US as the main guarantee to its national security. In the defence field, the Polish political and industrial strategies and decisions reflect this assumption. Major procurement contracts are usually assigned to US industry, such as in the case of Raytheon for the Patriot system, Lockheed Martin for the F-35, or Northrop Grumman for the Integrated Air and Missile Defense Battle Command System (IBCS).[209] With the US Democratic administration, industrial relations are likely to stay unaltered. What could change is Washington's level of commitment to the development of the EPAA system in Europe, also considering the likely attempt to return to the 2015 Joint Comprehensive Plan of Action (JCPOA) nuclear deal with Iran, and to rely less on nuclear arms in the US defence strategy. Currently, the Polish component of the EPAA in Redzikowo experienced delays, and its future will probably depend on the update of the missile threat assessment by the Biden administration, and maybe on a new Missile Defence Review (MDR).[210] Warsaw will push for a completion of the third stage of EPAA on its territory; however, it will not be able to count on the strong bilateral and personal relations established with Donald Trump. Biden's preference for multilateral fora in dealing with allies, coupled with the willingness to restore a positive relationship with Berlin and, last but not least, the divergences with Washington on domestic policy topics that are high on the President agenda, will make it more difficult for Poland to get the high level of attention it obtained

M.-Lakomy-Dylematy-polityki-bezpieczenstwa-Polski-publikacja-ksiazkowa.pdf.

207 Ibid.

208 Ibid.

209 Northrop Grumman, *Northrop Grumman Awarded $713 Million for Poland Next-Generation Air and Missile Defense*, 14 March 2019, https://news.northropgrumman.com/news/releases/northrop-grumman-awarded-713-million-for-poland-next-generation-air-and-missile-defense.

210 Marcin Andrzej Piotrowski, "Prospects for Missile Defence in Europe against Ballistic Threats from Iran", in *PISM Bulletin*, No. 242 (1672), 26 November 2020, https://pism.pl/file/86e96f93-5bc0-42f7-9e2f-35e2d1c26b6d.

in the last four years from the US. Potential requests for budget cuts on missile programmes by some groups in the Democratic party – as well as among the voters – and the Covid-19 impact on defence budget, could play a role as well.

8.3 Industrial, technological and capability dimension

Poland's Technical Modernisation Plan (*Plan Modernizacji Technicznej*) for 2021-2035, issued in October 2019, states that approximately 133 billion US dollars will be spent on procurement of new equipment and advanced capabilities for the Armed Forces in the next 15 years.[211]

AMD is among the key investment priorities, along with attack helicopters, rocket artillery, submarines, new generation main battle tanks and UAVs. Poland's defence industrial strategy is focused on enhancing and consolidating the national Defence Technology and Industrial Base (DTIB), mainly by involving it – and particularly the national champion Polska Grupa Zbrojeniowa (PGZ) – in procurement programmes. However, the overall technological level of the Polish DTIB is modest, making it impossible to rely only on domestic suppliers for the acquisition of complex platforms. The general approach is based on promoting offset and technology transfer agreements with foreign prime contractors seeking a "Polonisation" of these technologies.

Currently, air defence in Poland counts on obsolete, Soviet technologies and systems dating back to the 1960s and 1970s, that have been modernised only in part. This results in legacy solutions that have very limited operational effectiveness, if any, in contemporary conflicts. The last medium-range missile defence system ZROP-SZ 2K11 Krug was withdrawn in 2011, and should be replaced by the Wisła programme. Similarly, the Narew programme should replace legacy 2K12 KUB and 9K33 OSA systems,[212] and the SONA system should substitute the ZSU-23-4 SZYŁKA and ZSU-23-4MP BIAŁA AMD systems. The planned multi-layered IAMD in Poland includes three levels, each one corresponding to a different programme. The overall AMD architecture should encompass a VSHORAD[213] Pilica and Poprad programmes (first level), the Narew Short-Range Air Defence (SHORAD)[214] programme (second lower level layer with Polish radars and license-manufactured interceptors), and the Wisła Medium-Range Air Defence (MRAD)[215] programme (third, upper level layer with Patriot interceptors).

[211] Polish Ministry of Defence, *524 miliardy złotych na modernizację Wojska Polskiego do 2035 roku*, 10 October 2019, https://www.gov.pl/web/obrona-narodowa/524-miliardy-zlotych-na-modernizacje-wojska-polskiego-do-2035-roku.

[212] Michał Jarocki, "Major Polish Procurement Programmes", in *European Security & Defence*, No. 9/2020 (September 2020), p. 94-101, https://euro-sd.com/2020/09/articles/armed-forces/18858.

[213] VSHORAD systems that can hit targets in a range up to 10 km.

[214] SHORAD systems that can hit targets in a range from 10-to-50 km.

[215] Systems that can hit targets in a range over 50 km.

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Wisła programme

Wisła represents the most expensive programme in the Technical Modernisation Plan, aimed at defending the territory against tactical short-range ballistic missiles, cruise missiles, manned aircraft as well as UAVs. The system should be composed of 6 Raytheon's M903 Patriot mobile launchers (each capable of carrying 12 missiles/ interceptors), 208 PAC-3 MSE kinetic interceptors developed by Lockheed Martin, 4 radars AN/MPQ-65, an IBCS produced by Northrop Grumman with an Integrated Fire Control Network (IFCN). A second, "low-cost" interceptor should be integrated in the system.[216]

The modular, net-centric nature of the IBCS makes it the first air defence C2 system with such combat capabilities in the Polish inventory.[217] Its open architecture allows for interoperability with BMD systems. Poland could be the first country, outside the US, to integrate the Patriot batteries with IBCS, facilitating interoperability with the American and NATO militaries. Technology transfer and/or offset opportunities for Polish industry are being negotiated with Northrop Grumman.[218] Mobile communications nodes, rocket transport vehicles, F-OPS, C-OPS and E-OPS cabins are some of the equipments that should be produced by the Polish DTIB. The first procurement phase, signed in 2018, leads to the acquisition of two Patriot batteries that should be delivered by 2022, with IOC planned at the turn of 2023 and 2024.[219] The second phase is still under negotiations, and will concern the remaining 6 Patriot batteries, the AESA omni-directional radar, low-cost missiles – that will integrate the more costly MSE interceptor for use against less threatening targets, with CAMM-ER and Skyceptor currently in the running – and the IBCS.[220]

Difficulties in negotiating the offset package (Annex n°1) of the Wisła programme resulted in an impasse that potentially could delay the second phase of the procurement process.[221] The disagreement regards financing, auditing and licensing.[222] This may have domino consequences on other programmes. For

[216] One of the options considered is the SkyCeptor, jointly developed by Raytheon and Rafael Advanced Defence Systems, a second one is MBDA's Common Anti-air Modular Missile-Extended Range (CAMM-ER) interceptors. See: Jakub Palowski, "Wisła Programme: Transfer of Technology - Three Domains of Key Importance", in *Defence24*, 29 September 2017, https://www.defence24.com/wisla-programme-transfer-of-technology-three-domains-of-key-importance-analysis; Raytheon, *Missile Defence Update. Keeping Europe Safe*, November 2017, https://www.raytheon.com/sites/default/files/ourcompany/rtnwcm/groups/ids/documents/content/missile-defense-pdf.pdf.

[217] Jakub Palowski, "Wisła Programme", cit.

[218] Northrop Grumman, *Northrop Grumman Awarded $713 Million for Poland Next-Generation Air and Missile Defense*, cit.

[219] Polish Ministry of Defence, *Agreement for the "WISŁA" System*, 23 March 2018, https://www.gov.pl/web/national-defence/agreement-for-the-wisa-system.

[220] Ibid.

[221] Jędrzej Graf and Maciej Szopa, "Offset Wisły na kolejnym zakręcie. Budowa polskiej obrony powietrznej zagrożona", in *Defence24*, 26 September 2020, https://www.defence24.pl/kolejny-impas-w-negocjacji-offsetu-za-wisle.

[222] Ibid.

instance, capabilities to be obtained through the offset agreement have an influence on the Narew short-range programme as well.

Narew programme

Narew is considered to be the second "level", and the core, of Polish future IAMD. The system is thought to be complementary to Wisła, but its acquisition has been delayed by 5 years already.

PAC-3 MSE effectors to be used in Wisła have primarily a missile defence function and their range is wider than Narew. Whereas air defence is a secondary task for the Wisła programme, Narew – thanks to a higher number of launchers and radars, as well as to cheaper, mobile and more difficult to destroy missiles – should guarantee the "area (air) defence".[223] Complementarity among these programmes is favoured by the fact that only 8 batteries are planned to be acquired in the more expensive Wisła programme, compared with 19 up to 23 batteries planned for Narew.[224] The higher number of radars (even if covering a shorter range with respect to the Wisła radars) would guarantee the coverage of a significantly larger part of Polish soil. Wisła in fact provides a larger range, but a narrower line of sight, whereas Narew provides a shorter range, but a more distributed one. Currently the systems being considered are the National Advanced Surface to Air Missile System (NASAMS), developed jointly by Raytheon and Kongsberg Defence & Aerospace, and the Common Anti-air Modular Missile (CAMM) developed by MBDA.

The delays in procurement challenge the expected quality leap in Poland's IAMD, since only if both systems are connected in a way to exchange data and share responsibility on targets, they would significantly improve national IAMD capabilities.

Pilica and Poprad

Self-propelled anti-aircraft SAM Poprad is developed by the Polish Pit-Radwar (formerly Bumar Elektronika), part of PGZ group. The system is armed with legacy Grom effectors and/or their modernised version – Piorun missiles. Grom/Piorun are MANPADS operating heat-seeking missiles, manufactured by Polish Zakłady Metalowe Mesko. By 2022, the Pilica procurement should be concluded as well. This VSHORAD system will consist of six Anti-Aircraft Artillery (AAA) SAM batteries (each composed of six fire units), a command post, a radiolocation station, artillery tractors, and ammunition supply vehicles.[225] Similarly to Poprad, it will be armed with Grom/Piorun missiles. The system will be manufactured and delivered

[223] Marek Świerczyński, "Kluczowe rakiety bez decyzji. Gdzie wsiąkła Narew?", in *Polityka*, 28 February 2020, https://www.polityka.pl/tygodnikpolityka/kraj/1943536,1,kluczowe-rakiety-bez-decyzji-gdzie-wsiakla-narew.read.

[224] Ibid.

[225] Michał Jarocki, "Major Polish Procurement Programmes", cit.

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by a PGZ-Pilica consortium, composed of PGZ, Pit-Radwar, PCO and Zakłady Mechaniczne Tarnów.

Pit-Radwar will also produce IKZ-50P short-range Identification, Friend or Foe (IFF) Mark XIIA devices, to be integrated on both Poprad and Pilica systems.[226] According to the agreement, 64 units have been ordered with deliveries to be finalised by January 2024.[227]

8.4 Conclusion

The geopolitical position and national threat assessments make the Polish level of ambition for a modern IAMD quite high, in terms of both planned expenditure and cutting-edge systems. However, it remains to be seen whether the ensemble of current procurement plans is realistic and sustainable over time, and when the delivery of such complex systems will be completed. Foreseeable challenges include the fact that Covid-19 does impact on state budget and on timely deliveries of the systems. Secondly, the MoD's delays in choosing suppliers, awarding tenders and advancing with the procurement process (i.e. Narew) are significant. Thirdly, disagreements that emerged during negotiations with potential foreign suppliers on technology transfer and offset agreements (i.e. Wisła) to Polish industry, will probably repeat in the future, due to the complexity of the systems and of the size of the tenders at stake.

[226] Maciej Szopa, "Poland Procures IFF Systems for Poprad and Pilica Air Defence Assets", in *Defence24*, 16 March 2020, https://defence24.com/poland-procures-iff-systems-for-poprad-and-pilica-air-defence-assets-.

[227] Ibid.

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9. Turkey

by Can Kasapoğlu[228]

9.1 Introduction: Turkey's missile defence outlook

Back in 2005, a North Korea-manufactured Scud-D (No-Dong 1/Hwasong 7) fell on the Turkish territory during a Syrian missile test. Notably, the warhead exploded in the air-burst mode – the standard concept of operation for chemical weapons delivery.[229] The incident was monumental in marking the problematic threat landscape with which Ankara had to deal. Besides, Turkey did not have any capability to intercept the incoming threat at the time, and this has not changed to date.

Ballistic missiles are the ideal weapons of choice when it comes to deep-targeting and penetrating into hostile territory to destroy high-value political, military, and economic assets. Compared to manned aircrafts, they give minimum reaction time to the defending party. In other words, they can turn the adversary's entire territory into a battlefield, denying any "behind the front lines" area. Besides, ballistic missiles make ideal delivery means for WMDs. Even when intercepted at endo-atmospheric levels, WMD warheads can lead to serious contamination.[230] Overall, ballistic missiles are intra-war deterrence assets, suitable for controlling escalatory patterns within an ongoing conflict. Therefore Turkey, lacking adequate offensive or defensive strategic weapon systems, faces a significant "intra-war deterrence" gap in its defence planning.

9.2 Military-strategic and operational dimension: Turkey's decades-long intra-war deterrence gap

Turkey lives next to a problematic neighbourhood. Ankara's regional competitors enjoy menacing military capabilities that can target Turkey's critical national infrastructure, its major population centres, as well as military facilities situated in deep Turkish territory.

For decades, the Syrian Arab Armed Forces have proliferated a notorious ballistic missile arsenal coupled with lethal WMDs.[231]

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[229] Zachary Keck, "North Korea and Syria: A Chemical Weapons and Missile Dynamic Duo?", in *The Buzz*, 16 March 2018, https://nationalinterest.org/node/10380.

[230] Khalid Abdullah Al Bu-Ainnain, "Proliferation Assessment of Ballistic Missiles in the Middle East", in *Inegma Reports*, November 2009, p. 5-6, http://www.inegma.com/e-reportdetail.aspx?rid=46.

[231] Central Intelligence Agency (CIA), *Syria's Offensive Chemical Weapons Capability*, 1985 (approved for release in 2011).

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The ballistic missile dimension remains an important angle of the Turkish-Iranian military strategic balance, too. Although Turkey heavily dwarfs Iran when it comes to the conventional warfare, Iran's missile forces can hit anywhere across Turkey, including the nation's geopolitical core: Istanbul, the Marmara region, and the Straits. Having cunningly capitalised on the wording differences between the relevant UN Security Council Resolutions, the Iranian Revolutionary Guards Corps (IRGC) have tested several missiles to date, and continue boosting their offensive capacity. Furthermore, in 2017, the IRGC launched ballistic missiles from Iran into the reported buildup of ISIS in Eastern Syria, Deyrez-Zor – this sensational salvo marked Tehran's use of ballistic missiles in a real combat situation for the first time since the Iran-Iraq War.[232]

Turkey cannot match the abovementioned threat landscape by relying on its own ballistic missile programme. Indeed, in recent years Ankara has registered a notable improvement in the indigenous Bora ballistic missile system, delivering some 480 kg conventional warhead up to a 280 km range with a less than 50 m CEP. Still, Turkey's current defence technological and industrial base and missile know-how does not allow adding another stage to the Bora line to reach medium-range limits (1,000-to-3,000 km), at least in the foreseeable future.[233]

In sum, Turkish defence planners have to find a way to acquire effective missile defences while relying on NATO for a meaningful counter-balancer, as a panacea to the intra-war deterrence gap.

9.3 The S-400 saga: Turkey's "Russian roulette"

In recent years, Ankara's missile defence efforts have gained a bizarre, Russian dimension. Doubtlessly, the S-400 looms large as the most interesting and serious development of Turkey's defensive strategic weapons agenda.

The S-400 sale has gifted a very advantageous edge to the Russian Federation. Almaz-Antey, the primary manufacturer of the S-400, would secure around 13 per cent supplier share in Turkey's lucrative weapons market.[234]

Moreover, the S-400 deal – or any strategic SAM sale, to be more precise – can lead the way for additional transactions. Technically, AMD roles necessitate a network-centric approach that produces a layered configuration of various sensors, C2 nodes, and batteries working together – and this is why a Russian AMD system will not be compatible with Turkey's NATO-friendly systems infrastructure.[235]

[232] Ibid.

[233] Can Kasapoğlu, "Turkey's Nuclear Onset", in *SWP Comments*, No. 38 (October 2019), https://doi.org/10.18449/2019C38.

[234] Andrew Galer et al., "Turkey: Weapons Production and Procurement 2018–2027 Turkish Weapons", in I*HS Jane's*, March 2018.

[235] For a comprehensive guide to AMD, see: US Joint Chiefs of Staff, *Countering Air and Missile*

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Defensive strategic weapons, in a standard SAM configuration, are layered by mid-level assets (e.g. the Russian SA-17) and point defences (e.g. the Russian Pantsir short-to-medium-range air defence system, the SA-22 according to NATO's designation). Such SAM configurations depend on each system forming a different level of kill zone which they directly cover within their effective range.[236] At present, theoretically, the Turkish administration can well buy a Russian mid or low altitude air defence system (or both) to augment the S-400. In fact, in April 2018, Sputnik "advertised" the Pantsir to be "the logical next step" for Turkey.[237]

One thing is clear. The S-400 procurement, given its repercussions, stands more than an arms deal between a NATO and non-NATO nation. In the Kremlin's eyes, harming Turkey's transatlantic ties remains more charming than any S-400 price tag. At the time of writing, Turkey has started live-fire drills of the S-400 in the test ranges of the Black Sea city of Sinop.[238] The radar tests had already been conducted in 2019.[239] Overall, the S-400 activation – a political term more than a technical explanation – is almost completed.

Above all, the S-400 acquisition is likely to trigger the sanctions envisioned by the US Countering America's Adversaries Through Sanctions Act (CAATSA). The CAATSA content could even be tougher with the Biden presidency in the White House. In such case, Turkey's defence industry would face the grave threat of being cut-off from the Western, or at least American, defence eco-system. Second, the S-400 has already costed the Turkish Air Force a high burden through the halted F-35 procurement – an asset that can play an indispensable role in hunting the adversary's missile launchers in deep hostile territory.

9.4 Strategic AMD dimension in Turkey's defence technological and industrial base

Turkey's defence technological and industrial base has run a true leap over the past two decades. Ankara's long-term strategic planning, in addition to the country's economic uptrend in the early 2000s, facilitated a rich military modernisation agenda. Turkish weapons market remains extremely lucrative. Open-source databases suggest that, in 2018, Ankara spent some 12.98 billion US dollars in

Threats, 21 April 2017, https://www.jcs.mil/Portals/36/Documents/Doctrine/pubs/jp3_01_pa.pdf.

236 William A. Perkins, "Component Integration Challenges Presented by Advanced Layered Defence Systems (A2/AD)", in *The Three Swords Magazine*, No. 33 (2018), p. 52-64, http://www.jwc.nato.int/images/stories/threeswords/A2AD_2018.pdf.

237 "'Logical Next Step': Why Turkey May Need Russian Pantsir in Addition to S-400", in *Sputnik*, 27 April 2018, https://sputniknews.com/analysis/201804271063964243.

238 Özgür Altuncu, "'S-400'leri test ettik, ABD'ye soracak değiliz'", in *Hürriyet*, 24 April 2020, https://www.hurriyet.com.tr/gundem/s-400leri-test-ettik-abdye-soracak-degiliz-41644573.

239 İbrahim Kördemirci and Harun Özalp, "Son dakika haberleri: Ankara'da S-400 testi! İlk görüntüler geldi...", in *Hürriyet*, 25 November 2019, https://www.hurriyet.com.tr/gundem/son-dakika-haberleri-ankarada-s-400-testi-saat-verildi-41381808.

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defence, ranking the 7th within the Alliance and 18th globally.[240] Turkish military-industrial capacity has registered an exponentially growing number of indigenous and cooperative projects. Through expeditionary military campaigns in Syria, starting from the 2016 Operation Euphrates Shield up until now, Turkey's defence industries have showcased reliable indigenous weaponry in action under real warfighting conditions.

Turkey's tactical and Medium Altitude Long Endurance (MALE) drones, first and foremost Bayraktar TB-2 and ANKA, have proved themselves in the most daunting hybrid warfare battlefields of Syria. Especially, the Turkish drones' hunt for the Syrian Arab Armed Forces' Russian-manufactured Pantsir short-to-mid-range air defences has broadly resonated with the international strategic community.[241]

Ankara's defence modernisation strategic plans (2012-2016 and 2017-2021) aimed at boosting national industries' involvements in more ambitious projects. Notably, the 2018-2022 defence industry sectoral strategy document (*Savunma Sanayii Sektörel Strateji Dokümanı*) has set the aspirant goal of "technology and sub-systems ownership to facilitate a sustainable defense industry" to augment Turkey's newly developing strategic autonomy efforts.[242] At the time of writing, the updated 2019-2023 strategic plan, for the first time has prioritised managing technological transformation and generating the necessary elite workforce to enable Turkey's initiation into the next techno-scientific breakthrough.[243]

Turkish industries can now design and produce, albeit in various degrees of indigenous contribution, certain conventional warfighting assets such as corvettes, howitzers, smart munitions for drones, armored fighting vehicles and armored personnel carriers, and long-range sniper rifles. However, when it comes to strategic weapons and high-end arms, such as fifth generation aircrafts, long-range and high-altitude AMD systems, air-independent propulsion submarines, and amphibious assault vessels, the Turkish military needs international collaboration. Besides, Turkey's radars and sensors infrastructure is largely integrated with NATO's architecture and connected through a web of data-links to the transatlantic network. This C2 network cannot be altered given Turkey's struggle in high-tech algorithms and, broadly speaking, the Alliance's standards and requirements for a secure, integrated network.

In the foreseeable future, Turkish defence planning will continue to need NATO's support in missile defence, such as the X-band radar in Kurecik and the US Navy's

[240] IHS Jane's, *Navigating the Emerging Markets Report*, October 2018, p. 4.

[241] David Axe, "Guess Who Is a Drone Power Now? Turkey", in *The Buzz*, 17 March 2020, https://nationalinterest.org/node/133702.

[242] Turkish Presidency of Defence Industries, *2018-2022 Savunma Sanayii Sektörel Strateji Dokümanı*, 2018, https://www.ssb.gov.tr/Images/Uploads/MyContents/F_20190402102925477924.pdf.

[243] Can Kasapoğlu, "Turkey's Defense Outlook for 2020s Very Promising", in *Anadolu Agency*, 3 January 2020, http://v.aa.com.tr/1691178.

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Arleigh Burke-class destroyers in the Mediterranean. Besides, Turkey's indigenous missile defence project has been launched in cooperation with EUROSAM.

The EUROSAM pillar in Turkey's missile defence strategy has critical military and political aspects. Militarily, EUROSAM's SAMP/T option – the Aster line, in a broader spectrum –remains a promising opportunity for Turkey. At present, the system is capable of intercepting short-range ballistic missiles with up to 600 km range, along with air-breathing targets (cruise missiles, manned aircrafts and unmanned aerial vehicles), and providing 360 degrees coverage. The future variants will have the capability to address medium-range (1,000 km plus) ballistic missiles. The Aster-30 interceptor and further variants' tests include those against the Israeli Sparrow target-missiles which best mimic the Scud-derivative ballistic missiles, the dominant threat in the Middle East. Finally, the SAMP/T offers one-missile-for-all feature which makes it an ideal candidate for the Turkish Navy's sea-based AMD deterrent projects.[244] More importantly, the European option can, potentially, gift Turkey with something that neither the Russians nor the Americans have so far proposed, namely technology transfer and co-production.

At the political level, however, the souring relations between France and Turkey remain the biggest hindrance to the SAMP/T option. At this point, Italy, being a partner of EUROSAM, could take the diplomatic lead from Paris and pioneer the cooperation. If successful, such a diplomatic maneuver could mark the continuation of the "NATO character" of the Turkish strategic weapons arsenal, despite the S-400 "saga".

9.5 The transatlantic divide: lessons-learned from NATO support to Turkey against the Syrian Scuds

The Syrian conundrum has marked an important moment in Turkey's strategic ties with the Atlantic Alliance. Following the use of ballistic missiles and chemical weapons by the Baath regime in Syria, in late 2012 and early 2013, Ankara asked NATO for help, resembling the previous Iraqi crises. In 2013, the Netherlands, the US and Germany provided Ankara with six Patriot air and missile defence batteries. The deployment of Patriots showcased a firm allied support to Turkey's defence planning efforts. However, later on, all the initial Patriot provider countries decided to withdraw their assets from the Turkish soil (the Netherlands in 2014, the US, and Germany in 2015).[245] Although the allied explanations revolved around technical aspects, Turkey considered the decision to be overshadowed by political divergences in Syria.[246]

[244] For a reference study, see: Can Kasapoğlu, "The Military Strategic Rationale of Turkey's T-Loramids Project and the Eurosam Offer", in *FRS Recherches & Documents*, No. 1 (August 2014), https://www.frstrategie.org/en/node/1977.

[245] Burak Ege Bekdil, "US, Germany to Withdraw Patriots from Turkey", in *Defense News*, 17 August 2015, https://www.defensenews.com/land/2015/08/17/us-germany-to-withdraw-patriots-from-turkey.

[246] Uğur Ergan, Celal Özcan and İpek Yezdani, "NYT: Patriot'ların çekileceği söylendiğinde Türk yetkililer mosmor oldu", in *Hürriyet*, 18 August 2015, http://www.hurriyet.com.tr/dunya/nyt-

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While the withdrawals exacerbated a shock among the Turkish policy community, the contingents were later replaced by Italian SAMP/Ts and Spanish Patriots, still within the NATO framework. Furthermore, the Alliance's 2018 Brussels Summit Declaration labelled Syrian missiles hitting the Turkish soil as an urgent issue to address. Yet, in October 2019, when Ankara launched a large-scale military campaign in North-Eastern Syria (Operation Peace Spring), a serious drift surfaced with the West, along with arms exports restrictions. This time, Italy decided to remove the SAMP/T batteries as a pronounced reaction to the Turkish campaign,[247] while Spain opted for keeping its Patriots, thus remaining the only NATO nation present in the area.[248]

NATO Headquarters have prioritised keeping the withdrawals limited to bilateral agendas between allied nations, not a common issue of the Alliance as such. However, Secretary General Stoltenberg declared that the deployments should continue as an emblem of allied solidarity, despite the differences between NATO members.[249]

Nevertheless, the Syrian Scuds episode highlighted both domestic missile defence shortcomings and the Turkish administration's political drift with its traditional allies. This dichotomy is also reflected in Ankara's contemporary dilemmas in missile defence. Turkey's strategic weapons agenda continues to be stuck between its capacity and its desired end-state – and this reality is not going to change soon.

9.6 Conclusion

Turkey remains a NATO nation bordering Iran, Iraq, Syria, the Mediterranean, the Black Sea and the Caucasus. Geopolitically, this unfavourable positioning marks a nation at the crossroads of various flashpoints. Besides, the country faces various hybrid risks, ranging from Salafi extremist terrorism to WMDs proliferation. Thus, the Turkish military has to ensure a high level of readiness to tackle national security threats across the spectrum.

Turkey has to address troublesome challenges concerning strategic AMD. For decades, the lack of defensive strategic weapons has led to a problematic capability shortfall against the Middle Eastern ballistic missile and WMD trends. Moreover,

patriotlarin-cekilecegi-soylendiginde-turk-yetkililer-mosmor-oldu-29837490.

[247] Tom Kington, "Italy to Remove Its Air-Defense Assets from Turkey by Year's End", in *Defense News*, 25 October 2019, https://www.defensenews.com/global/europe/2019/10/25/italy-to-remove-its-air-defense-assets-from-turkey-by-years-end.

[248] Sevil Erkuş, "Spain Extends Patriot Deployment since NATO Ally's Security Is Crucial: Ambassador", in *Hürriyet Daily News*, 16 December 2019, http://www.hurriyetdailynews.com/spain-extends-patriot-deployment-since-nato-allys-security-is-crucial-ambassador-149868.

[249] Sebastian Sprenger and Tom Kington, "Amid Syria Discord, NATO Chief Backs Continued Deployment of Allies' Air Defenses in Turkey", in *Defense News*, 24 October 2019, https://www.defensenews.com/global/europe/2019/10/24/amid-syria-discord-nato-chief-backs-extending-air-defense-help-to-turkey.

A2/AD bubbles surrounding Turkey make skies, especially in deep strike missions, extremely risky for the Turkish Air Force's operations. The very fact that Ankara currently does not operate stealth aircrafts, and is out of the F-35 consortium, brings about an additional risk in this sense. Indeed, pre-emptive strikes against mobile and silo-based ballistic missile launchers is no easy way-out for Turkish defence planners.

Lastly, although technology transfer and co-production remain Turkey's two priorities with respect to its defence modernisation, when it comes to high-end weaponry supplier nations are generally not keen to share their critical know-how.

Ankara faces grim limitations. In the early 2000s, the contribution of domestic defence industries to the Turkish Armed Forces' warfighting capabilities remained below 20 per cent. At the time of writing, this contribution has reached a very positive level of 65 per cent. Yet, as to high-end weaponry, be it strategic SAM systems, fifth generation fighters, advanced submarines, or airborne early warning and intelligence aircraft, Ankara has to rely on foreign suppliers. Missile defence is a clear manifestation of this bitter truth for Turkey.

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10. United Kingdom

by Sidharth Kaushal[250]

This Section will seek to lay out the key features of the UK's approach to missile defence, its historical trajectory and future prospects. As the first nation to come under direct missile attack during the second world war, the threat posed by long-range strike assets has played a meaningful role in British security debates over the course of the 20th Century and into the 21st.[251] However, policymaking with regards to missile defence has – at least as far as homeland BMD is concerned – been characterised by a historic ambivalence regarding both its utility and desirability – especially since the UKs nuclear deterrent was deemed sufficient to prevent the use of WMDs tipped missiles against the homeland.[252] At the level of theatre and tactical level threats, cruise missile defence has received some attention, particularly following the Argentine Air Force's demonstration of the lethality of cruise missiles in conventional conflicts at sea during the Falklands War.[253]

In the present environment, some of the strategic and operational considerations that informed previous policy consensus on missile defence have been invalidated. Opponents such as Russia can use cruise and ballistic missiles, along with hypersonic boost glide vehicles, as conventional prompt strike assets against the UK homeland to paralyse the British Armed Forces, instead of using them exclusively as a means for delivering a WMD. Secondly, the threat at the tactical-operational level has become more complex. As the decade moves on, UK policymakers will confront two major questions:

- Does the UK need some form of limited ground-based IAMD for the homeland to secure it against conventional strike assets?
- At the tactical-operational level, how must AMD adapt to a changing environment?

10.1 The history of missile defence in the UK

During the Cold War, the threat posed by ballistic missiles was apparent. However, as the prospect of missile defence emerged in the 1960s and 1970s, UK policymakers had misgivings regarding both the technical viability of missile defence systems and their value against a nuclear arsenal the size of Soviet Union's.[254] Nonetheless, the UK did agree to the placement of part of the US' Ballistic Missile Early Warning System (BMEWS) on its soil. A decision was reached for an Ultra High Frequency

[250] Sidharth Kaushal is Research Fellow in Sea Power at the Royal United Services Institute (RUSI).

[251] Jeremy Stocker, *Britain and Ballistic Missile Defence, 1942-2002*, London/New York, Frank Cass, 2004.

[252] Ibid., p. 197-220.

[253] Anthony H. Cordesman and Abraham R. Wagner, *The Lessons of Modern War, Vol. III: The Afghan and Falklands Conflicts*, Boulder, Westview Press, 1991, Ch. 3.

[254] Jeremy Stocker, *Britain and Ballistic Missile Defence*, cit., p. 75-76.

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(UHF) early warning radar to be placed at Royal Air Force (RAF) Fylingdales base, jointly resourced by both countries and manned by RAF personnel.[255] The radar was not a missile defence asset *per se*, but could be a component of the early warning system enabling US missile defence. In the 1980s, the UK maintained its policy of ambivalence towards the Strategic Defence Initiative (SDI) – agreeing to join research efforts with the Reagan administration, but stopping short of accepting Secretary of Defence Weinberger's offer of joint development and fielding. In addition to scepticism regarding feasibility, worries regarding the destabilising effects of missile defence played a role.[256] This policy of hedging continued after the Cold War. British policymakers avoided to emulate the Clinton administration's planned National Missile Defence or to commit to support the Bush administration's plan for Global Protection Against Limited Strikes (GPALS). However, Britain did agree to upgrade the Fylingdales radar and accede to the placement of a site at RAF Menwith hill, which would act as a communications relay for the Space-Based Infrared Sensor system in this period. While not exclusively missile defence related, both systems would be critical to US early warning in the event of a missile strike, and are key enablers for BMD.[257]

At the operational-tactical level, the UK's 20th Century efforts at missile defence against cruise missiles were coordinated at the single service level. After the 1998 Strategic Defence Review (SDR), GBAD was consolidated under the joint ground-based air defence headquarters. This headquarters was under effective control of the RAF, albeit with personnel from the Royal Artillery.[258] The UK maintained no defence against theatre ballistic missiles during this period, but did contribute significantly to NATO's ALTBMD system for the coordination of Alliance efforts against theatre ballistic missiles, once an agreement over the system was reached.

Overall, the British approach to missile defence has been to hedge. While Britain has contributed to allied efforts at BMD, and has conducted research independently, it has averred from committing to the development of missile defence capabilities while leaving the door open to doing so if and when the technology matures. At the theatre/tactical level, the UK has invested in defences against air breathing cruise missiles.

[255] Graham Spinardi, "Golfballs on the Moor: Building the Fylingdales Ballistic Missile Early Warning System", in *Contemporary British History*, Vol. 21, No. 1 (2007), p. 87-110.

[256] Trevor Taylor "Britain's Response to the Strategic Defence Initiative", in *International Affairs*, Vol. 62, No. 2 (Spring 1986), p. 217-230.

[257] Mark Bromley and Tom McDonald, "Keeping Tabs on Big Brother: UK Debates US Plans for Ballistic Missile Defence", in *BASIC Papers*, No. 34 (September 2000), http://basicint.org/wp-content/uploads/2018/06/PUB010900.pdf; Jeremy Stocker, Britain and Ballistic Missile Defence, cit., p. 195-203.

[258] UK Government, *Strategic Defence Review*, Cmnd 3999, July 1998, para. 33.

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10.2 Current policy, organisation and capabilities

The current policy on BMD is an evolution on the prior consensus. In the 2015 Strategic Defence and Security Review (SDSR), the government of the day committed itself to contribute to NATO by continuing "to commit significant funds to the NATO Ballistic Missile Defence (BMD) network, as well as supporting research and development initiatives and multinational engagement through the UK's Missile Defence Centre".[259] The UK currently contributes with 10 per cent of the costs of NATO missile defence, including the ALTBMD C2 structure and the Alliance's Aegis Ashore sites.[260] The review also committed Britain to enhancing NATO's progress towards a 360 degree missile defence system, by building a ground based UK missile defence radar.[261] The precise location of this radar was left unstated, with the sovereign base in Cyprus being one possibility. A ground-based long-range radar in Cyprus could potentially expand NATO's coverage against Southern facing threats, for example.

The other commitment made in the 2015 SDSR was to assess the potential for the Type-45 destroyer to play a BMD role through PAAMS.[262] The Type 45 is an air defence-guided missile destroyer equipped with a SAMPSON multifunction AESA radar and the Aster interceptor family, which was co-developed with European partners. The SAMPSON radar on the Type-45 can certainly track ballistic threats, and has done so in NATO exercises such as Formidable Shield.[263] If equipped with a BMD interceptor such as the Aster-30 Block 1NT missile, the vessel could provide coverage for carrier battle groups against anti-ship ballistic missiles, as well as protecting the homeland against intermediate-range ballistic threats.[264] At present, the Type 45 fields the Aster-30 Block 0, which functions as a medium-range AMD system. Given the limited number of destroyers, however, there will likely not be enough Type 45 DDGs[265] afloat to perform both roles at any given time even if they are made BMD capable.

The UK's joint GBAD capabilities have now been shifted from the RAF to the Army's 7th Air Defence Group, which has been stood up once more.[266] The movement of

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[259] UK Government, *National Security Strategy and Strategic Defence and Security Review 2015*, Cm 9161, London, The Stationery Office, 2015, para. 4.16, https://www.gov.uk/government/publications/national-security-strategy-and-strategic-defence-and-security-review-2015.

[260] Anthony Wraight, *The UK MoD Approach to Missile Defence*, Presentation delivered at the "Air and Missile Defence Conference 2017", Hamburg, 26-28 September 2017, https://www.ccsbamd.org/competence-centre/wp-content/uploads/2017/10/112_20170914-GBR-Perspective.pdf.

[261] UK Government, *National Security Strategy and Strategic Defence and Security Review 2015*, cit., para. 4.16.

[262] Ibid.

[263] UK Ministry of Defence, *UK at Heart of International Missile Defence Exercise*, 24 September 2017, https://www.gov.uk/government/news/uk-at-heart-of-international-missile-defence-exercise.

[264] George Allison, "Aster Missile to Gain Anti-Ballistic Missile Capability", in *UK Defence Journal*, 15 November 2016, https://ukdefencejournal.org.uk/?p=4981.

[265] NATO classification: Guided missile destroyer.

[266] UK Army, *Launch of New Joint Air Defence Group*, 5 April 2019, https://www.army.mod.uk/news-

control over GBAD to the Army is indicative of a growing understanding of the threat faced by manoeuvring ground forces by cruise missiles, among other air-based threats.[267] To meet this challenge, the Army has adopted the Land-Ceptor system, which can target air-breathing threats at ranges of 25 km – well in excess of the radius of its predecessor, the Rapier.[268] The system is based around the Saab Giraffe air defence radar and the CAMM, which was developed by MBDA in concert with NATO Allies France and Italy. The missile module was intended to provide a shared interceptor for both ground and naval forces.[269] The battle management system for the UK's GBAD will be based around Rafael's Multi-Level Integrated Command, Control and Communications Air Defence (MIC4AD) system, which is utilised to integrate Israel's multi-tiered missile defences.[270]

The risks posed to AMD systems supporting a forward-based manoeuvring force by threats ranging from artillery to UAVs – which can overwhelm them with massed fire – will mean that, in many cases, these forces will need off-board cueing from vessels at sea and assets in the air. Turning on a ground radar for active search in such an environment is highly risky, as this discloses one's own location to adversaries.[271] As such, the need to triangulate between passive detection by the Giraffe radar and data from sensors held by other services will be critical. It is notable, given this requirement, that while interceptor procurement was coordinated between the Army and the Navy, the procurement of battle management systems was not. This is not insurmountable. Nonetheless, it is a task with which UK defence will need to grapple.

At sea, the Royal Navy will utilise the CAMM, which can be launched from both the Type-45 destroyer and the Type-26 Frigate. The SAMPSON AESA radar on board the Type-45 will provide the vessel with the capacity to track and engage large numbers of air breathing threats, which will be critical in an environment in which carrier strike groups and their pickets will be challenged by a range of anti-ship missiles of increasing speed and sophistication.[272] As mentioned earlier, the multifunctional SAMPSON radar can enable the detection and tracking of intermediate-range ballistic threats. Given that the Type-45 can launch BMD interceptors such as the Aster-30 from its Sylver VLS, this should enable a degree of defence against intermediate-range ballistic threats for either carrier battle groups

and-events/news/2019/04/launch-of-new-joint-air-defence-group.

267 Jonathan Parrott, *7ADG*, Speech delivered at the "RUSI Missile Defence and Space Conference 2020", London, 26 February 2020.

268 MBDA, *Final Configuration of the British Army's Land Ceptor Unveiled*, 12 September 2019, https://www.mbda-systems.com/?p=14528.

269 MBDA website: *CAMM (Land Application)*, https://www.mbda-systems.com/?p=4092.

270 Army Technology, *Sky Sabre: Inside the UKs Missile Defence System*, 25 April 2018 (last updated 8 July 2020), https://www.army-technology.com/features/sky-sabre-inside-uks-missile-defence-system.

271 Jonathan Parrott, *7ADG*, cit.

272 Sidharth Kaushal, "A Critical Enabler For Power Projection. Options for UK Missile Defence in an Age of Escalation Control", in *RUSI Occasional Papers*, May 2019, p. 33, https://rusi.org/node/26069.

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or the homeland, depending on how assets are allocated.[273]

Finally, in terms of defending the homeland against missile threats, the major non-naval asset fielded by the UK is the RAF's Typhoon fleet. While these assets could not engage a ballistic threat they could, in principle, intercept a cruise missile using their meteor air to air missiles – though the range at which intercepts can be performed is limited.[274]

The UK's Missile Defence Centre (MDC) acts as the main interface between the MoD and industry partners for both Research and Development (R&D) efforts and procurement. The UK's domestic technological base has supported its missile defence enterprise in a number of areas. Companies such as BAE were central to the development of the SAMPSON multifunction radar, for example. The development of the UK's future at sea BMD system will be a multinational project pursued via collaboration between BAE and MBDA. MBDA UK is pursuing exploratory work on IAMD algorithms and adapting existing systems architecture to enable simultaneous AMD engagements, while exploratory work on the development and production of interceptors is being conducted in collaboration with partners in France and Italy.[275]

Additionally, the work of the MDC with regards to producing software to support the simulation of BMD operations and the development of data fusion systems to enable the integration of third party data has been abetted by collaboration between the MDC and UK based companies such as L-3 ASA and Qinetiq.

The UK's technological base, then, is largely set up to examine the non-kinetic aspects of missile defence, including sensors and C2 architectures, while relying on work done by partners such as the French division of MBDA for work with regards to the production of hit to kill interceptors.

10.3 Conclusions and future trajectories for UK missile defence

At present, the future trajectory of UK procurement looks set to build on existing foundations. Programmes such as the development of a BMD capability for the Type-45 through the introduction of a new interceptor, as well as the introduction of software aboard the vessels to allow them to conduct simultaneous engagements of air and missile threats, will enhance the UK's capacity for at sea missile defence. On land, missile defence is still largely focused on short-range defence against air-breathing threats. Future efforts in this area will largely focus on networking, both across the joint force and with partners.

273 Ibid., p. 36.

274 Mark Gunzinger et al., "Towards a Tier One Royal Air Force", in *CSBA Studies*, 29 March 2019, p. 48, https://csbaonline.org/research/publications/towards-a-tier-one-royal-air-force.

275 Anthony Wraight, *The UK MoD Approach to Missile Defence*, cit.

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As the UK contemplates its future missile defence capabilities, it will need to ponder two questions:

- Whether the homeland and critical military infrastructure such as air bases can be defended against conventional missile attacks without stripping forward forces of strike assets;
- How the joint force integrates sensors and shooters across the land, sea and air domains.

With regards to the first question, in the face of opponents such as Russia, which can launch long-range conventional strike assets such as the Kinzhal and KH-101 from its strategic bombers against the homeland, the UK faces the risk of operational paralysis in the early days of a campaign, as key bases and C2 nodes can be hit. This risk can, of course, be mitigated, but not without stripping assets such as the Type-45 or the Typhoon from front line forces. As such, policymakers will likely need to contend with how some form of limited homeland IAMD can be provided.

Secondly, given the need for off-board sensors from across the services to support each other, particularly in the context of GBAD missions in a contested theatre, it will require a degree of systems integration across the UK's three services as well as coordinated procurement.

11. United States

by Ian Williams[276]

The US is a world leader in the development and deployment of AMD systems. Its layered Ballistic Missile Defense System (BMDS) is the most comprehensive deployed in the world today, a network of systems built to counter ballistic missiles of varying ranges and phases of flight. In addition to building out its own defences, the US has also sought to strengthen the missile defence capabilities of its allies and partners. As aerial threats have grown more diverse to include more advanced cruise missiles and drones, there has been increasing demand by the US military for IAMD systems capable of engaging a broader spectrum of threats.

11.1 Evolution of US missile defence policy

After the terrorist attacks of September 11th, 2001, the George W. Bush administration sought to dramatically reform the US security posture, which included withdrawing the US from the ABM Treaty in 2002. The Pentagon then established the Missile Defense Agency (MDA), an independent Defense Department agency. The Secretary of Defense endowed the MDA with unique acquisition and budgetary authorities to enable it to move systems from development to fielding more quickly.[277] The Bush administration envisioned a system that could adapt promptly to emerging threats, declaring that "the United States will not have a final, fixed missile defense architecture".[278]

In 2010, the Obama administration released the Ballistic Missile Defense Review (BMDR), a first-of-its-kind statement of US missile defence policy. The BMDR articulated the goals of US missile defence as maintaining an "advantageous" position relative to small powers like North Korea, while defending against a large-scale attack from major powers like Russia was "not the focus of U.S. BMD". The BMDR also declared that the US would "reject any negotiated restraints on U.S. ballistic missile defenses".[279]

In 2019, the Trump administration released the MDR. The MDR affirms many of the basic principles of the BMDR, including the limited scope of US homeland defence. By contrast, though, the MDR takes a more holistic view of missile threats,

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[277] US Secretary of Defense, *Missile Defense Program Direction*, Memorandum, 2 January 2002, http://library.rumsfeld.com/doclib/sp/2477/2002-01-02%20to%20Deputy%20Secretary%20of%20Defense%20et%20al%20re%20Missile%20Defense%20Program%20Direction%20with%20Attachments.pdf.

[278] White House, *National Policy on Ballistic Missile Defense*, National Security Presidential Directive 23, 16 December 2002, https://www.hsdl.org/?abstract&did=439067.

[279] US DoD, *Ballistic Missile Defense Review Report*, February 2010, p. 4, 34, https://www.hsdl.org/?abstract&did=16640.

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calling for capabilities to defeat non-ballistic threats like cruise missiles, drones, and new hypersonic weapons. The MDR also expressed the need to look beyond active defences, emphasising the need to incorporate strike and other means of disabling enemy missiles before launch.[280] The policy even inches closer to calling for defences against certain kinds of Russian and Chinese missile threats, noting that "Russia and China are developing advanced cruise missiles and hypersonic missile capabilities […] These are challenging realities of the emerging missile threat environment that U.S. missile defense policy, strategy, and capabilities must address."[281] The MDR failed, however, to make decisive policy moves that would significantly improve US defences against a major military power.[282]

11.2 US missile defence strategy

While US missile defence capacity remains limited, it has become important to US military strategy. Missile defence is in high demand by combatant commanders, owing to concerns that an enemy could use missiles to debilitate forward-deployed US forces and facilities in a conflict, particularly in its early phases. The mission of missile defence in this context is to ensure the survival of US and allied forces until they can begin offensive operations.

The US also uses missile defence as a tool for strategic signalling and allied assurance. In 2013, the US deployed Patriot units to Turkey at the request of Ankara, which was concerned about potential threats emanating from Syria. This move took place under the NATO umbrella, and the activity has seen the rotating participation of several Allies in recent years, including Germany, the Netherlands, and Spain. President Obama leaned on missile defence to allay concerns of Gulf Cooperation Council (GCC) countries over the Iran nuclear deal.[283] In 2020, the US temporarily deployed AMD units to Saudi Arabia, following Iran's attack on the Abqaiq and Khurais petroleum facilities. Moreover, American strategists consider homeland missile defence as a tool to boost the credibility of US security guarantees abroad, under the logic that such capability makes it harder for adversaries to use missiles to weaken US resolve to intervene on its allies' behalf.

11.3 The US missile defence system

Since 2002, the US military has fielded multiple missile defence systems, including the Ground-based Midcourse Defense (GMD) system, Aegis BMD, the Terminal High Altitude Area Defense (THAAD), and further upgrades to the Patriot system.

280 US DoD, *Missile Defense Review*, 2019, p. 35, https://www.hsdl.org/?abstract&did=820401.

281 Ibid., p. iv.

282 Thomas Karako, "The Missile Defense Review: Insufficient for Complex and Integrated Attack", in *Strategic Studies Quarterly*, Vol. 13, No. 2 (Summer 2019), p. 3-15, https://www.airuniversity.af.edu/Portals/10/SSQ/documents/Volume-13_Issue-2/Karako.pdf.

283 Abel Romero, "Thanks Obama: Tracking the President's Missile Defense Embrace", in *RealClearDefense*, 26 January 2017, https://www.realcleardefense.com/articles/2017/01/27/the_presidents_missile_defense_embrace_110702.html.

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The Pentagon refers to this group and its supporting systems as the BMDS.

Most US missile defence systems use kinetic kill or "hit-to-kill technology". This approach uses chemically-powered rockets equipped with non-explosive warheads called "kill vehicles". Kill vehicles are fitted with infrared/electro-optical sensors and divert thrusters, which they use to locate an incoming warhead, manoeuvre into its path, and collide with it.[284]

The central integrating element for the BMDS is the Command and Control Battle Management and Communications (C2BMC) programme. Although each system employs its own fire control mechanisms, C2BMC permits coordination between missile defence assets, thus providing a common picture of the battlespace. This allows for high-level battle management of engagements to avoid interceptor wastage. Lockheed Martin is the prime contractor for C2BMC.

GMD

GMD is the US' homeland missile defence system, built to intercept intercontinental ballistic missiles. US policy declares that this system will engage ICBM threats regardless of their geographic origin. However, GMD's configuration is most suited to defend the US against the North Korean missile threat. This orientation is perhaps most evident when looking at the positioning of GMD's supporting sensors, predominantly located in the Pacific theatre. The prime contractor for GMD is the Boeing Company.

GMD employs large, three-stage rockets called Ground-Based Interceptors (GBIs). There are currently 44 GBIs, mostly based in Alaska. The 2019 MDR directed the deployment of an additional 20 GBIs, though this expansion is unlikely to happen until MDA completes the current GBI modernisation programme, sometime in the late 2020s or early 2030s.[285]

Unlike other missile defence systems like THAAD or Aegis, GMD has no primary or "organic" sensor. Instead, GMD's fire control system draws data from a network of sensors deployed across the world. These include Upgraded Early Warning Radars (UEWRs), the Cobra Dane radar in Alaska, and the Sea-based X-band radar. GMD can also pull in data from radars onboard Aegis BMD ships and forward-based TPY-2 radars via C2BMC. The US is currently building a large new radar in Alaska, the Long-Range Discrimination Radar (LRDR), which will primarily serve the GMD system. The primary contractor for the LRDR is Lockheed Martin.

[284] Divert thrusters are small liquid-fueled engines that allow a kill vehicle to make fine adjustments to its flight path.

[285] Timothy Wright, "US Missile Defense Agency Seeks Proposals for Next Generation Interceptor", in *IISS Blogs*, 10 June 2020, https://www.iiss.org/blogs/analysis/2020/06/mdi-next-generation-interceptor.

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Aegis BMD

Aegis is the sea-based leg of the BMDS. It builds upon the Aegis Weapon System, the US Navy's primary air defence platform. It employs the SM-3 interceptor, the SPY-1 radar, and the Aegis Combat System (ACS) C2 framework. Future US Aegis ships will use the new SPY-6 radar, which has a greater range, among other improvements. The US has also developed a land-based version of the system called Aegis Ashore.

There are several variants of the SM-3 in service or development. The current workhorse of Aegis BMD is the Standard Missile-3 Block IB (SM-3 IB) and its enhanced "Threat Upgrade" version (SM-3 IB TU). The SM-3 IB can intercept short to intermediate-range ballistic missiles during midcourse flight. The latest development is the SM-3 Block IIA (SM-3 IIA). The SM-3 IIA is substantially larger than previous blocks, with greatly increased range and defended coverage area. The SM-3 IIA can even outfly the maximum tracking range of a SPY-1 radar. To exploit its full kinematic ability, the SM-3IIA features "engage on remote" capabilities, allowing an Aegis BMD platform to launch and engage a missile target entirely on data from an integrated forward-based radar. MDA stated in June 2019 that the SM-3 IIA development is now complete, and the interceptor is ready for production.[286]

Aegis BMD also employs the Standard Missile-6 (SM-6), a long-range air defence interceptor that MDA has upgraded to conduct terminal phase engagements of ballistic missiles. This dual configuration has made SM-6 a useful counter to the threat of anti-ship ballistic missiles such as those developed by China. The Pentagon is also reportedly evaluating the SM-6 as a counter to aerial hypersonic weapons, with a potential flight test against a hypersonic glide body in 2023.[287]

The Aegis Weapon System more broadly employs several other kinds of interceptor missiles for aerial defence. The Raytheon-produced SM-2 has been a mainstay of US Navy air defence for decades. Its most recent variants, the SM-2 Block III, Block IIIA, and IIIB are deployed in multiple navies within NATO. SM-2 is exclusively an air defence interceptor and does not have capability against ballistic missile targets. The most modern variant, the SM-2 Block IIIC, incorporates the active seeker from the SM-6, enabling the interceptor greater autonomy and lessening demand on a ship's fire control capacity. Still in development, the SM-2 IIIC will likely reach its initial operating capability in 2023.[288]

[286] Megan Eckstein, "MDA Director Says SM-3 Block IIA Ready for Production, Unrelated to Japan's Decision to Back Out of Aegis Ashore", in *USNI News*, 19 June 2020, https://news.usni.org/?p=77688.

[287] Jason Sherman, "DOD Eyes SM-6 for Counter-Hypersonic Mission, Test Against Glide-Vehicle Target in FY-23", in *Inside Defense*, 12 March 2020, https://insidedefense.com/node/206817.

[288] Richard Scott, "Canada Approved for SM-2 Block IIIC Missile Purchase", in *Janes Defence News*, 6 November 2020, https://www.janes.com/defence-news/news-detail/canada-approved-for-sm-2-block-iiic-missile-purchase.

The primary defence contractor for the ACS is Lockheed Martin. Raytheon produces the SM-2, SM-3, SM-6 as well as the SPY-1 and SPY-6 radars. Lockheed Martin has developed its own radar, the SPY-7, which is compatible with Aegis and is getting incorporated into some future Aegis platforms such as Spain's future F-110 frigates.[289]

THAAD

THAAD is a land-based BMD system capable of intercepting short to intermediate-range ballistic missiles. Produced by Lockheed Martin, THAAD can engage targets in the upper atmosphere and low exo-atmosphere, which lets it fill the engagement space between Aegis and Patriot. THAAD employs the TPY-2 X-band radar for tracking and fire control. A TPY-2 can also operate as a standalone sensor supporting the broader BMDS. The US Army possesses seven THAAD batteries, two of which are permanently stationed in the Asia-Pacific region on the US territory of Guam and in the Republic of Korea.

Patriot

The Raytheon-built MIM-104 Patriot is a US AMD system and represents the core of the US Army Air Defense Artillery Branch. The Army fields 15 Patriot battalions. One battalion is permanently stationed at Ramstein Air Base, Germany, with three more assigned to the Asia-Pacific theatre. The remaining battalions are located at Army posts in the US and regularly rotate to deployments in the Middle East. Patriot is a point defence system, meaning its defended area is relatively small and must be near the sites it wishes to protect. As such, the US military most often uses Patriots to defend high-value installations like forward airbases and command centres.

There are several different interceptor variants employed by Patriots today. The most common is the PAC-3, which was the first Patriot interceptor to employ hit-to-kill technology as opposed to blast fragmentation. Hit-to-kill offers higher kill confidence against ballistic missiles, particularly those with separating warheads. The PAC-3 remains in production today as the PAC-3 Cost-Reduction Initiative (PAC-3 CRI). The newest variant, the PAC-3 MSE, features greater speed, range, and manoeuvrability. In addition to Patriot, Germany plans to use PAC-3 MSE in its TLVS AMD system. Other interceptors in use include the blast-fragmentation GEM series (GEM-T & GEM-C) – versions of the PAC-2 interceptors enhanced for defence against ballistic and cruise missiles, respectively.

[289] Martin Manaranche, "Spain Awards Lockheed Martin $519m For F-110 Aegis & SPY-7 Radar Systems", in *Naval News*, 27 April 2020, https://www.navalnews.com/?p=10597.

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11.4 Future trends: towards IAMD

For much of the past two decades, US missile defence programmes have focused on the ballistic missile threat. Since the mid-2010s, however, there is a growing awareness that the spectrum of aerial threats is growing more diverse and complex. The proliferation of cruise missiles and drone technology has brought a host of new, low-flying weapons that challenge defence systems optimised for ballistic missiles. This incongruence has driven US interest in developing IAMD systems capable of engaging both air and space-breathing threats.[290]

Currently, the closest thing to an IAMD system that the US is the ACS. The most recent ACS versions, Baselines 9 and 10, integrate Aegis's BMD and air defence capabilities through a single multi-mission signal processor. This upgrade permits an Aegis platform to toggle between performing air defence and BMD seamlessly, adding significant mission flexibility. Moreover, Aegis's modular Mk 41 vertical launching system can launch numerous types of effectors, providing multiple layers of defence from a single launcher.

Adding another dimension to Aegis IAMD is the NIFC-CA concept. Its central goal is to create a kill chain that enables Aegis ships to engage aerial targets over the horizon, beyond the reach of their organic sensors. NIFC-CA uses the Cooperative Engagement Capability (CEC) datalink to transmit fire control data from aircraft like the E-2D Advanced Hawkeye and, in the future, the F-35. Such integration significantly increases a ship's AMD battlespace.

Patriot also has IAMD characteristics. For example, interceptors can engage both ballistic missiles and aerial threats. The US is also working to enhance the integration of its Patriot units. Presently, Patriot can only draw fire control data from its own collocated sensor. This limits the variety and trajectories of threats that a Patriot unit can handle at any given time. The Army is seeking to remove this limitation. In the near term, the military has been working to integrate Patriot and THAAD, so that a Patriot can use the tracks from a TPY-2 radar.[291] The Army is also continuing to develop the IBCS, which will permit Patriot to use fire control data from other integrated sensors. Produced by Northrop Grumman, IBCS should expand Patriot's air defence battlespace and improve its mission flexibility.

As the spectrum of air and missile threats expands, the US is also looking to widen the mission of its missile defences. The emergence of new aerial hypersonic weapons such as scramjet-powered cruise missiles and hypersonic glide vehicles has prompted the Pentagon to examine active defence options. The first counter

[290] See: US Joint Chiefs of Staff, *Joint Integrated Air and Missile Defense: Vision 2020*, 5 December 2013, https://www.jcs.mil/Portals/36/Documents/Publications/JointIAMDVision2020.pdf.

[291] Jen Judson, "So Patriot and THAAD Will Talk. What Does That Really Mean?", in *Defense News*, 10 October 2018, https://www.defensenews.com/digital-show-dailies/ausa/2018/10/10/so-patriot-and-thaad-will-talk-what-does-that-really-mean.

hypersonic systems could be modified versions of existing interceptors, such as SM-6. US government officials have stated that the US would likely not deploy a dedicated hypersonic defence system until at least the mid-2020s.[292]

There are two US government programmes underway pursuing counter-hypersonic development. One is the MDA's Hypersonic Defense Regional Glide Phase Weapon System (RGPWS), which seeks to develop and mature the technologies necessary for a hypersonic defence system.[293] Another similar line of effort is the Glide Breaker programme, within the Defense Advanced Research Projects Agency (DARPA).[294]

11.5 US missile defence contributions to NATO

Since its withdrawal from the ABM Treaty, the US has sought to use missile defence as a tool to enhance NATO security and cohesion. It pursues this through the direct deployment of US missile defence to Europe and efforts to build greater interoperability between the national AMD forces of NATO members. These efforts include contributing to joint NATO missile defence exercises, such as Formidable Shield in 2019 and Tobruq Arrows in 2020. The centrepiece contribution to NATO missile defence, though, has been the deployments made under the EPAA.

US efforts towards a major BMD deployment to Europe began in 2007, when the George W. Bush administration negotiated a plan to emplace ten, two-stage ground-based interceptors in Poland supported by an X-band radar in the Czech Republic. The Obama administration cancelled this proposed architecture in 2009 with a new initiative called European Phased Adaptive Approach. The EPAA deployments have come in three phases. The first phase included the permanent stationing of four Aegis BMD-equipped destroyers in Rota, Spain, as well as a TPY-2 X-band radar in Turkey to provide early warning and tracking of missile threats emanating from the Middle East. Phase II constituted the construction of an Aegis Ashore site in Romania. The final planned deployment will be a second Aegis Ashore site at Redzikowo, Poland, due for completion by 2022. The Aegis Ashore site in Romania employs the SM-3 IB, and both sites will have the SM-3 IIA when it becomes available.

The EPAA is the only element of the NATO missile defence system capable of providing wide-area defensive coverage of Europe. To accomplish this, the Aegis Ashore sites depend on the early tracking data from the TPY-2 radar in Turkey. The tracks this radar provides allows for an SM-3 IB to launch on remote, giving it

[292] Jen Judson, "MDA Pauses Defensive Hypersonic Missile Design to Refocus Plan", in *Defense News*, 4 August 2020, https://www.defensenews.com/digital-show-dailies/smd/2020/08/04/mda-pauses-defensive-hypersonic-missile-design-effort-to-refocus-plan.

[293] US DoD, *Hypersonic Defense Regional Glide Phase Weapon System, Draft Request for Prototype Proposal*, 30 January 2020, p. 8, https://beta.sam.gov/opp/e01d8ad5d7134a97a0ff0c5cac0021da/view.

[294] Nathan Greiner, "Glide Breaker", in *DARPA*, https://www.darpa.mil/program/glide-breaker.

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enough coverage area to defend central and South-Eastern Europe. Once the US deploys the SM-3 IIA interceptor to Romania and Poland, the TPY-2 will permit these interceptors to engage on remote, enabling the sites to defend nearly all NATO territory in Europe.

This reliance on a single radar may present a vulnerability to the system. Should the TYP-2 fail, be it from mechanical problems or enemy action, the Aegis Ashore sites' defended coverage could shrink dramatically. Adding capacity and redundancy to the EPAA sensor architecture is a ripe area for potential allied contributions to NATO missile defence.[295]

The four destroyers based at Rota contribute to NATO defence by acting as surge assets to augment the Aegis Ashore installations and to provide defence of Turkey and other territories that fall outside of the Aegis Ashore sites' coverage area. As multimission assets, the destroyers are also available to respond to other NATO and non-NATO contingencies as well. For example, the 2017 US strike against Shayrat Airfield in Syria in response to the Assad regime's use of chemical weapons was carried out by two of the destroyers at Rota.[296]

11.6 Conclusion

Although stunted by decades of treaty restrictions, US missile defence has grown well out of technological infancy into a core military capability that the US military and its allies depend upon daily. The diversity of missile threats that the US and NATO face requires looking beyond old distinctions between BMD and AMD towards IAMD architectures. Furthermore, new hypersonic weapons like the boost-glide vehicle will require novel systems and approaches. No single nation can do it all, and cooperation within Alliance frameworks like NATO is vital to counter these evolving adversary capabilities.

295 Ian Williams, "Achilles' Heel", cit.

296 USS Ross (DDG-71) and USS Porter (DDG-78).

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12. Treaties and control regimes

by Federica Dall'Arche and Ottavia Credi[297]

Major multilateral and bilateral efforts have been undertaken to discourage the spread of sensitive materials and technologies necessary for the development of missiles and other Delivery Systems (DSs). While the instruments deriving from such efforts are mostly voluntary, they serve – or have served, in the case of the ABM Treaty and the INF Treaty – as important Transparency and Confidence-Building (T&CB) measures.

12.1 Multilateral treaties

MTCR

The Missile Technology Control Regime (MTCR) is an informal political agreement that aims at curbing the proliferation of missiles and missile technology.[298] Established in 1987 by the G7 countries, it currently counts the membership of 35 states.[299]

Initially conceived to cover only ballistic missiles, the regime now consists of a set of Guidelines and an Annex that regulate the development, production, and operation of WMDs' DSs, including nuclear-capable missiles,[300] UASs, and related materials and technologies (e.g. computer softwares).

The Guidelines constitute the regime's common export control policy, and guide members in their exporting activity. For instance, the Guidelines provide a list of factors that MTCR partners need to consider prior to exporting, such as the recipients' credibility and known or alleged intentions with regards to WMDs' acquisition or production.[301]

The Annex lists types of equipment and technologies needed for missile development, production and operation into two categories: Category I includes items of great sensitivity and whose export is rare (e.g. complete rockets, UASs, DSs); Category II includes items frequently exported, mostly because they are technologies or products which also have civilian uses (e.g. propulsion and

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298 MTCR website: *Frequently Asked Questions (FAQs)*, https://wp.me/P7XAPI-2R.

299 For a complete list of MTCR's partners, see MTCR website: *MTCR Partners*, https://wp.me/P7XAPI-7.

300 At the time of signature, nuclear-capable missiles were defined as rocket systems and UAVs with a range of at least 300 km and able to carry at least 500 kg of payload.

301 MTCR website: *MTCR Guidelines and the Equipment, Software and Technology Annex*, https://wp.me/P7XAPI-k.

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propellant components).[302]

The regime presents several limitations. For one, adherence is only possible upon members' consensus, making the regime particularly exclusive[303] and possibly preventing countries with important missiles programmes and proliferation potential from joining the regime.[304] Additionally, the MTCR has no legally-binding mechanisms to enforce compliance and is, therefore, practically unverifiable. Lastly, the regime classifies UASs and missiles under the same category, ignoring important technological evolutions.[305]

In July 2020, citing the rapidly changing technological environment and in an effort to incentivise the sale of American UASs, the Trump administration announced the unilateral reinterpretation of the MTCR's rules.[306]

Wassenaar Arrangement

In 1996, 42 states party to the MTCR decided to take a step further by adopting the Wassenaar Arrangement on Export Controls for Conventional Arms and Dual-Use Goods and Technologies.[307] Building upon the MTCR, the Arrangement consists of a voluntary-based export control regime aimed at promoting responsibility and transparency. To achieve such goal, among other things, members must exchange information concerning their exporting activities and commit to raising awareness regarding proliferation risks related to such activities.

HCoC

The Hague Code of Conduct (HCoC, formerly known as the International Code of Conduct - ICoC), was established in 2002 to complement the MTCR, applying further restrictions to the development, testing and deployment of ballistic missiles capable of delivering WMDs and Radiological Dispersal Devices (RDDs).

The Code is an informal political arrangement that provides principles, guidelines, commitments, and T&CB measures. Differently from the MTCR, the regime is open

[302] MTCR website: *Equipment, Software and Technology Annex*, https://wp.me/P7XAPI-m.

[303] For this reason, the regime has been accused of being discriminatory and elitist. See: Chin-Hao Huang, *"Bridging the Gap": Analysis of China's Export Controls against International Standards*, UK Foreign & Commonwealth Office, May 2012, https://www.gov.uk/government/publications/analysis-of-chinas-export-controls-against-international-standards.

[304] Peter Van Ham, "The MTCR at 30. Ideas to Strengthen the Missile Technology Control Norm", in *Clingendael Policy Briefs*, November 2017, https://www.clingendael.org/node/8707.

[305] Paola Sartori, "The Missile Technology Control Regime and UAVs: A Mismatch between Regulation and Technology", in *IAI Commentaries*, No. 17|32 (December 2017), p. 2, https://www.iai.it/en/node/8638.

[306] Christopher Ashley Ford, *The New U.S. Policy on UAS Exports Under the MTCR*, July 2020, https://www.state.gov/The-New-U.S.-Policy-on-UAS-Exports-Under-the-MTCR.

[307] For further information, see the official website: https://www.wassenaar.org.

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to all states and currently counts the membership of 140 countries.[308]

Among other obligations, the HCoC requires subscribing states to exchange information and release an annual declaration on their ballistic missiles and space launch vehicles' programmes and policies. The Code also requires Pre-Launch Notifications (PLNs) for related launchers and test flights. Members are prohibited from assisting other countries' programmes and must, rather, support efforts against the proliferation of ballistic missiles, and advocate for cooperation in peaceful access to space. In favour of transparency, the Code also provides for international observers to inspect members' launch sites.

As the only multilateral instrument governing non-proliferation of ballistic missiles, the HCoC represents an important politically-binding agreement, besides a successful example of soft law.[309] Nonetheless, the regime presents some limitations. Firstly, it does not impose legal obligations and lacks verification mechanisms. Moreover, the regime only focuses on ballistic missiles, ignoring other DSs like UASs, manned bombers or cruise missiles. Lastly, the Code lacks the participation of countries particularly active in the field of ballistic missiles such as Iran, China and North Korea. In this regard, in 2019, the Permanent Mission of Italy to the International Organizations in Vienna invoked further participation in the HCoC worldwide.[310]

PSI

The PSI was established in 2003 by the then-US President Bush to increase international cooperation against the transfer of WMDs, their DSs, and related materials. To become a member, states have to endorse the PSI Statement of Interdiction Principles,[311] a set of guidelines on transfers. Today, the regime counts 107 parties. In virtue of the initiative, members can interdict shipments of illicit WMDs-related materials to and from states and non-state actors.[312] Activities of the PSI are supervised by 21 members, which form an Operational Experts Group (OEG).[313]

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[308] For a complete list of the members of the Hague Code of Conduct (HCoC), see: HCoC website: *Subscribing States*, https://www.hcoc.at/?tab=subscribing_states&page=subscribing_states.

[309] Lucia Marta, "The Hague Code of Conduct Against Ballistic Missile Proliferation: 'Lessons Learned' for the European Union Draft Code of Conduct for Outer Space Activities", in *ESPI Perspectives*, No. 34 (June 2010), p. 2, https://wp.me/p6prAM-4y.

[310] "Italia a Vienna sostiene universalizzazione Codice Aja contro proliferazione missili balistici", in *OnuItalia*, 3 June 2019, https://www.onuitalia.com/italia-a-vienna-sostiene-universalizzazione-codice-aja-contro-proliferazione-missili-balistici.

[311] For further information, see: Proliferation Security Initiative (PSI), *Proliferation Security Initiative: Statement of Interdiction Principles*, 14 May 2018, https://www.psi-online.info/psi-info-en/botschaft/-/2077920.

[312] Emma Belcher, "The Proliferation Security Initiative. Lessons for Using Nonbinding Agreements", in *CFR Working Papers*, July 2011, p. 1, https://on.cfr.org/3weOHIN. For the complete list of members and further information about the PSI, see PSI website: https://www.psi-online.info.

[313] PSI website: *Operational Experts Group*, https://www.psi-online.info/psi-info-en/

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12.2 Bilateral treaties (US-Russia)

During and after the Cold War, both Washington and Moscow engaged in a series of agreements to limit their missile and anti-missile programmes. Some of these agreements are still relevant today.

ABM Treaty

The 1972 ABM Treaty was one of the first bilateral efforts in this sense. Negotiated in the context of the Strategic Arms Limitation Talks I (SALT I),[314] the ABM posed serious limitations to the number of ABM systems deployable by each country and established a diplomatic channel through the Standing Consultative Commission (SCC).[315] The Treaty ceased to be effective in 2002 after the US, concerned about the impossibility to develop a defence programme against ballistic threats from terrorist organisations or rogue states, unilaterally withdrew from it.

INF Treaty

The INF Treaty was another historic arms control bilateral agreement. Signed in 1987, as the result of decade-long talks, the Treaty provided for the elimination of all (nuclear and conventional) ground-launched ballistic and cruise missiles with a range between 500 and 5,500 km.[316] By 1991, the two parties successfully destroyed 2,692 missiles and ceased the production, testing and deployment of additional ones.[317]

To verify compliance and ensure mutual transparency, the INF Treaty included on-site inspections as well as satellites and remote sensing capabilities, to detect the other party's arsenal.

The INF constituted one of the first steps towards bilateral US-USSR cooperation on strategic armaments reduction, and one of the most enduring regimes of its type. However, in August 2019 the US formally withdrew from the INF citing Russian violations.[318] Such claims had already been supported by NATO in 2018, which

themen/-/2077926.

[314] For further information, see NTI website: *Strategic Arms Limitation Talks (SALT I)*, last updated 26 October 2011, http://nti.org/48TAR.

[315] For further information, see: US Department of State, *Fact Sheet: Regulations of the Standing Consultative Commission*, 26 September 1997, https://1997-2001.state.gov/global/arms/fs-abm_scc_regs_970926.html.

[316] Treaty Between the United States of America and the Union of Soviet Socialist Republics on the Elimination of Their Intermediate-Range and Shorter-Range Missiles (INF Treaty), 20 August 2019, http://nti.org/8TAR.

[317] Center for Arms Control and Non-Proliferation, *Fact Sheet: Intermediate-Range Nuclear Forces (INF) Treaty*, October 2018, https://armscontrolcenter.org/?p=6707.

[318] The US accused Russia of developing 9M729 cruise missiles. Although Russia confirmed such production, it firmly denied violation of the Treaty, affirming that such missile was never tested

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affirmed that the Russian SSC-8/9M729 missile violated the Treaty and posed a significant risk to Alliance's security.[319]

Over the duration of the agreement, accusation of alleged violations and non-compliance were reciprocal and recurrent,[320] but they were not the only reason for dismissal. Over the years, both sides showed serious preoccupations regarding the Chinese fast-developing nuclear and missile programme.[321] The US suggested to include China in the agreement, yet all proposals advanced by China were deemed incoherent with the US policy. In particular, China proposed "a non-destabilising anti-missile defence policy" and a no-first-use agreement with regard to nuclear weapons. It also encouraged proposing ways in which the counting and verification methods of bilateral arms control agreements could be adapted to the Chinese context.[322]

The demise of the INF Treaty constitutes a major setback for the arms control regime. Furthermore, it diminishes the security of the European continent which, if it were not for the New Strategic Arms Reduction Treaty (New START) – an instrument analysed below – would find itself between two un-regulated major nuclear powers and a potential new nuclear arms race.[323]

New START

The New START is a pillar bilateral arms control agreement. Signed in 2010, and entered into force on February 5th, 2011, the Treaty was adopted following the expiration of the Strategic Arms Reduction Treaty (START I)[324] and the Strategic Offensive Reduction Treaty (SORT),[325] a series of sequential agreements aimed at reducing US and Russia's nuclear weapons and DSs.

nor able to fly at the range prohibited by the INF. See: Chris Miller, "The INF Treaty Is Dead, and Russia Is the Biggest Loser", in *Foreign Policy*, 2 August 2019, http://bit.ly/2YCE2JQ; Daryl Kimball, "The Intermediate-Range Nuclear Forces (INF) Treaty at a Glance", in *ACA Factsheets*, August 2019, https://www.armscontrol.org/factsheets/INFtreaty.

[319] NATO, *NATO and the INF Treaty*, 2 August 2019, https://www.nato.int/cps/en/natohq/topics_166100.htm.

[320] The US claimed Russia violated the INF by testing and deploying the SSC-8 cruise missile (2011) and testing the RS-26 Rubezh ICBM (2012); Russia accused the US (2000) of breaching the terms of the Treaty by developing a target missile (Hera), by installing MK-41 launchers in Eastern Europe (2016) which exceed the ranges set by the Treaty, and by arming drones (2019). See: Center for Arms Control and Non-Proliferation, *Fact Sheet: Intermediate-Range Nuclear Forces (INF) Treaty*, cit.

[321] Caitlin Talmadge, "The US-China Nuclear Relationship: Why Competition Is Likely to Intensify", in *Brookings Reports*, September 2019, https://brook.gs/2m9VROU.

[322] Emmanuelle Maitre, "What Prospects for Arms and Missile Control After the End of the INF Treaty?", in *FRS Recherches & Documents*, No. 3 (February 2020), p. 9, https://www.frstrategie.org/en/node/2762.

[323] Ibid., p. 3.

[324] For further information, see: US Department of State archive, *Strategic Arms Reduction Treaties, 1991 and 1993*, https://2001-2009.state.gov/r/pa/ho/time/pcw/104210.htm.

[325] For further information, see: Daryl G. Kimball, *The Strategic Offensive Reductions Treaty (SORT) at a Glance*, in *ACA Factsheets*, September 2017, https://www.armscontrol.org/factsheets/sort-glance.

While imposing new tight limitations to the nuclear arsenals and DSs of both parties,[326] which were met by February 5th, 2018, the New START also establishes verification and T&CB measures, such as periodical exchanges of sensitive data concerning missiles and DSs, and a fix number of on-site inspections.[327]

The Treaty, with an original duration of ten years (until February 5th, 2021), was recently renewed for another five years with a last-minute agreement made by the newly elected US President, Joe Biden, and the Russian President, Vladimir Putin, just days before the Treaty's expiration. Such renewal came after months of failed negotiations between the Putin administration and the one of former US President Donald Trump, with the latter claiming alleged – yet unverified – Russian violation of the Treaty[328] and insisting on the inclusion of China into the negotiations for a potential new agreement.[329] As one of its very first executive actions, on February 3rd, 2021, Biden agreed on the renewal of the New START without preconditions, effectively leaving the Treaty into effect until February 5th, 2026.[330]

Over the years, the New START has represented an important channel for bilateral communication and cooperation.[331] Its extension, therefore, represented a fundamental step towards arms control and as well as an important mutual commitment towards strategic collaboration and mutual transparency. Failing to renew the New START would have significantly compromised the arms control regime, possibly creating the conditions for a new nuclear arms race.[332]

[326] The Treaty set a limit of 1,550 deployed strategic warheads and weapons, 800 deployed and non-deployed ICBMs and SLBMs launchers and bombers, and 700 delivery systems (ICBMs and SLBMs) and heavy bombers equipped for nuclear weapons. See: Center for Arms Control and Non-Proliferation, *Fact Sheet: Understanding the New START Agreement*, 19 January 2017, https://armscontrolcenter.org/?p=6579.

[327] Specifically eighteen. Some conducted on a short notice and directly at the site with deployed strategic launchers (Type I), others performed at bases with non-deployed DS (Type II). See: Ibid.

[328] Pranay Vaddi, Nicholas Blanchette and Garrett Hinck, "What Happens If the Last Nuclear Arms Control Treaty Expires?", in *Carnegie Q&A*, 5 September 2019, https://carnegieendowment.org/publications/79782.

[329] With an arsenal of about 10 per cent of that of respectively the US and Russia, China has shown no intention to take part in a trilateral agreement of this sort. See: Hans Kristensen and Matt Korda, "Status of World Nuclear Forces", in *FAS Issues*, last updated March 2021, https://fas.org/?p=12747; Associated Press, "China 'Has No Interest' in Joining US-Russia Nuclear Deal", in *AP News*, 13 May 2019, https://apnews.com/50c0fb070533401fab1143d61e0cdb21.

[330] US Department of State, *On the Extension of the New START Treaty with the Russian Federation*, 3 February 2021, https://www.state.gov/on-the-extension-of-the-new-start-treaty-with-the-russian-federation.

[331] Brian L. Sittlow, "New START: The Future of U.S.-Russia Nuclear Arms Control", in *CFR In Briefs*, 28 January 2020, https://www.cfr.org/node/223610.

[332] Ibid.

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13. Ten key points for Italy's missile defence

by Alessandro Marrone and Michele Nones[333]

13.1 A persistent missile threat worsened by hypersonic weapons

As discussed in previous sections, Europe's missile defence has been a key element of the Cold War – as well as of its end. It is part of a broader military-technological edge experienced by the West so far. Such an edge is currently at stake because of the geopolitical competition with world and regional powers, the changes in technological innovation, and the technology transfers requested to Western aerospace and defence companies by possible recipients of their exports.[334] Today, missile systems are accessible for several states, and their more widespread versions are at hand also for non-state actors. This is particularly worrying for Europe, which can be threatened by missile attacks from both world powers and regional actors. The demise of the INF Treaty has further worsened the regional security environment.[335] Noticeably, those types of weapon systems have the potential to impact the military and security balance of a region, therefore influencing relations among major players – especially competing ones. Consequently, the procurement and deployment of missile technologies, both offensive and defensive, have to be carefully assessed in light of the strategic context in which NATO operates, taking into consideration potential changes in the regional balance that such systems could entail, as well as the risk of arms race dynamics.

When looking at missile capabilities outside NATO, it should be reminded that ballistic missiles are valued because they can deliver a relatively large warhead across borders to great distances in a short time.[336] They can be launched with little or no warning, fly to their assigned targets autonomously, and penetrate all but the most sophisticated defensive systems. These attributes make ballistic missiles an attractive option for delivering nuclear weapons. It is no coincidence that each of the world's nine nuclear-armed nations fields advanced ballistic missiles to deliver them. Non-nuclear weapons states also covet ballistic missiles for similar reasons. For some, most notably Iran, ballistic missiles provide an extra-territorial strike option and an alternative to advanced aircrafts.[337] North Korea viewed ballistic missiles similarly, and its interest in this field has been further reinforced by its recently acquired nuclear capabilities.

Against this backdrop, hypersonic weapons do represent the current technological frontier. Today, most of ballistic missiles' flight out of the atmosphere is already

[333] The authors do thank Stefano Silvestri and Vincenzo Camporini for the feedbacks received, and do take full responsibility of the Section's content.

[334] See in this regard Section 1.

[335] See in this regard Section 12.

[336] See in this regard Section 3.

[337] Ibid.

beyond Mach 5. The new class of systems that is currently being developed, including Hypersonic Cruise Missiles (HCMs) and HGVs, will be capable of flying hypersonics also within the atmosphere, thus dramatically decreasing the time needed to reach the target. Furthermore, by staying in such altitude's range, hypersonic weapons evade both BMD and traditional AMD, since they fly too low for the former and too high for the latter.[338] While the speed of hypersonics is much greater than the speed of sound, their further advantage lies in their enhanced maneuverability, and in a smoother flight path which is much harder to track than that of traditional missiles.[339] Moreover, glide vehicles will offer even greater maneuverability than ballistic missiles, thus further complicating the engagement by defence effectors. As a matter of fact, within this decade, hypersonic weapons will be able to conceal their target until few seconds before they reach it.[340] The impact's kinetic energy will suffice to destroy the target even without a warhead,[341] while conventional or nuclear explosive would add further destructive power. In a nutshell, hypersonic weapons appear to be a true game-changer, as they strongly amplify the attributes of air power (speed, range, flexibility and precision), and offer the potential for military operations from longer ranges with a shorter response time and enhanced effectiveness, if compared to current military systems.[342]

As a result, current missile defence system would not be able to ensure a protection sufficient to guarantee a second strike possibility anymore,[343] with a negative, far-reaching implication on nuclear deterrence and strategic stability.[344] It is not by chance that China, Russia and the US are heavily investing in hypersonic weapons, followed by France and India.[345] Japan, the UK and Australia are the countries furthest behind in terms of development.[346] For instance, Moscow is testing the 3M22 Tsirkon cruise missile featuring hypersonic speed, initially intended for an anti-ship role but possibly offering the basis for a land-attack weapon.[347] Actually, hypersonic missiles represent a threat for strategic targets in NATO countries homeland, including capitals, headquarters, and the very IAMD capabilities.

338 Audrey Quintin and Robin Vanholme, "Hypersonic Missiles and European Security", cit.

339 Ibid.

340 Michele Nones, Paola Sartori and Andrea Aversano Stabile, "La difesa missilistica e l'Italia", cit., p. 14.

341 Richard H. Speier et al., "Hypersonic Missile Nonproliferation. Hindering the Spread of a New Class of Weapons", in *RAND Research Reports*, 2017, https://doi.org/10.7249/RR2137.

342 Audrey Quintin and Robin Vanholme, "Hypersonic Missiles and European Security", cit.

343 Ben Brimelow, "Hypersonic Weapons Can Make Virtually All Missile Defenses Useless - And Destabilize the World Order", in *Business Insider*, 4 March 2018, https://www.businessinsider.com/hypersonic-weapons-could-nullify-missile-defenses-2018-2.

344 The strategic reflection on deterrence goes beyond the scope of this study, since it entails a focus not only on missile defence but also on offensive capabilities, arms control, and an overarching strategy linking defence, deterrence and détente.

345 James Bosbotinis, "Hypersonic Missiles: What Are They and Can They Be Stopped?", in *Defence IQ*, 28 August 2018, https://www.defenceiq.com/defence-technology/news/hypersonic-missiles-what-are-they-and-can-they-be-stopped.

346 Richard H. Speier et al., "Hypersonic Missile Nonproliferation", cit.

347 See in this regard Section 2.

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13.2 The Euro-Atlantic landscape of missile defence

As mentioned in previous sections, NATO plays a fundamental role in ensuring Europe's IAMD and, over the last decade, it has made substantial progresses on BMD through the US' EPAA system and the assets offered by Germany, Poland, Spain and Turkey. The Alliance's C2 architecture constitutes the backbone for integrating the variety of capabilities owned by member states into what has become a cornerstone of current nuclear deterrence and collective defence. In 2017, the EU begun to contribute to missile defence trough PeSCo projects and the EDIDP funding, in particular with the TWISTER programme led by Paris and participated by Berlin, Madrid, Rome, The Hague and Helsinki.

In this context, the US is the leading power in the development and deployment of missile defence systems. The 2019 MDR takes a holistic view, calling for capabilities to defeat diverse threats like cruise missiles, drones, and new hypersonic weapons – explicitly noting certain Russian and Chinese capabilities.[348] Since 2002, the US military has fielded multiple missile defence systems, including the GMD systems, the Aegis BMD, the THAAD, and further upgrades to the Patriot system. Interestingly, Washington recently boosted the budget for the MDA's Hypersonic and Ballistic Tracking Space Sensor (HBTSS) programme – focused on providing continuous coverage for homeland defence as a lower layer within the National Defense Space Architecture (NDSA), especially from fast-flying cruise missiles – as well as for the Hypersonic Defense RGPWS.[349] The Pentagon is considering the construction of a network of space-based sensors to identify missile launches earlier in their flights, giving the defender more time to respond to an impending attack.[350]

Among NATO European countries, France considers missile defence as an extension of air defence. Through the development of SAMP/T and PAAMS, both in cooperation with Italy, Paris got an initial missile defence capability independent from the US. While recognising the EPAA's essential role for Europe's comprehensive missile defence, France would strive for an architecture where European political authorities and industries retain control,[351] In operational terms, missile defence is under the sole authority of the Air Force. In industrial terms, MBDA France, Thales and the French part of Airbus are the major players in the missile defence field and cooperate with European or American counterparts.[352] Against this backdrop, for Paris integrating missile defence in a European framework is essential, and

[348] See in this regard Section 11.

[349] Jane Edwards, "MDA Eyes Regional Approach to Hypersonic Missile Defense", in *ExecutiveGov*, 19 December 2019, https://www.executivegov.com/?p=198359.

[350] Richard Weitz, "Managing Multi-domain and Hypersonic Threats to NATO", in *ICDS Commentaries*, 24 April 2020, https://icds.ee/en/?p=48220.

[351] See in this regard Section 5.

[352] Ibid.

elements of the solution are emerging through a number of PeSCo projects led or participated by France, first and foremost TWISTER.

For historical and geographic reasons, Germany holds a strong position in NATO IAMD architecture, also by hosting at Ramstein Air Base the Allied Air Command, in charge of IAMD itself. Berlin is concerned about missile defence proliferation. In terms of procurement, Patriot is going to be replaced by the TLVS produced by Lockheed Martin and MBDA Germany, with components from Leonardo, while the next generation of six F-127 frigates are designed to fulfill all endo-atmospheric missile defence tasks, including addressing hypersonic missiles.[353] Noticeably, in 2019, Berlin started a process to procure a space-based early warning and target designation system for missile defence including against hypersonic weapons and, in 2020, it joined TWISTER.[354] Interestingly, the German MoD considers only certain IAMD components as key technologies to be developed by domestic suppliers like MBDA Germany, Diehl, Hensoldt and Rheinmetall, while other components – including effectors – can be acquired from foreign partners.

The UK's traditional approach to missile defence has been hedging: contributing to allied efforts on BMD, but not committing to developing capabilities, while leaving the door open to do so in the future.[355] British ground-based air defence has been shifted from the Air Force to the Army, and the UK is going to procure the CAMM-ER system developed by MBDA in concert with France and Italy. At the same time, the multifunction SAMPSON radar can enable the detection and tracking of intermediate-range ballistic threats, and the Aster-30 should provide a degree of defence against them. Future missile defence developments will come from a multinational project pursued via a collaboration between BAE and MBDA, and exploratory works on the development of interceptors is being conducted with partners in France and Italy.[356]

Poland's geopolitical position makes it particularly exposed to traditional security threats from Russia. Accordingly, the current Polish National Security Strategy states that the military should ensure the state's capability for effective air defence, including missile defence.[357] In 2020, the defence budget did grow by 11 per cent, reaching the 2.1 per cent of GDP.[358] Since large part of the Polish military equipment, including IAMD, is obsolete, the Armed Forces' Technical Modernisation Plan for 2021-2035 envisages approximately 133 billion US dollars to be spent on procurement of new equipment and advanced capabilities. In this context, the programmes Wisła, Narew, Pilica and Poprad are particularly relevant

[353] See in this regard Section 6.
[354] Ibid.
[355] See in this regard Section 10.
[356] Ibid.
[357] See in this regard Section 8.
[358] Ibid

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for Polish BMD capabilities.[359] Moreover, as mentioned before, Poland hosts the second Aegis Ashore site in Redzikowo.

13.3 Ten key points for Italy's approach

On the basis of the analysis conducted in previous sections, and particularly in light of the worsening missile threats and the Euro-Atlantic landscape, the following key points should influence Italy's approach to missile defence.

First, NATO remains the strategic and operational cornerstone of Europe's missile defence, and this task in going to gain further relevance within the Alliance's renewed focus on collective defence and nuclear deterrence. Therefore, Italy's efforts should always be coherent with allied IAMD architecture and the requirements laid down through the NATO Defence Planning Process (NDPP). Recent and foreseeable evolutions of allied missile defence should be duly taken into account, in order to both contribute to address current weaknesses and play on Italy's strengths in geographic, military, technological and industrial terms. At the same time, Rome should insist on involving EU institutions in the NDPP, in order to ensure more coherence between the respective visions, requirements and investments.

Second, European cooperation, mainly but not only through EU defence initiatives, has become the main channel to develop robust missile defence capabilities in a more effective and sustainable way. As a result, Italy should plan capability development and industrial policy in this field, primarily looking for cooperation with major European allies – namely France, Germany, and possibly the UK and Poland – and preferably using PeSCo and EDF tools. In other words, while NATO provides the transatlantic politico-military architecture for missile defence, the EU should be the incubator of military-industrial cooperation to deliver next generation capabilities. Accordingly, Italy should commit adequate resources on TWISTER as a flagship project with France and Germany, but also on all related PeSCo initiatives, and particularly in the space domain. In a similar vein, Rome should look at EDF calls in a proactive, timely and comprehensive way, to decide priorities and co-funding. Both within PeSCo and the EDF, such a commitment should be timely, in order to better position Italian industries vis-à-vis competitors and partners. These resources should be coupled by a political, diplomatic and military effort to move European defence cooperation forward, as the only way to deliver adequate capabilities which no single country in Europe can afford on its own. European governments should recognise the need for cooperation and incentivise the respective industries to adopt a win-win, cooperative approach to missile defence. Joint procurement or at least cross-procurement should follow. In this contest, the regulation allowing British entities to participate in PeSCo projects and EDF calls should be fully exploited with regards to missile defence, in order to reach a European critical mass and achieve economies of scale from both

[359] Ibid.

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the demand and the supply side.

Third, as mentioned in previous sections, in order to address current and upcoming missile threats, a range of sensors is required to find, identify and track hostile missiles. These ideally will include a space-based launch detection capacity combined with space-based, ground-based and ship-borne radars, also for early warning and for in-flight tracking and target discrimination, while a digital battle management backbone will be also needed.[360] Actually, the radar systems, sensor suites, C2 and battle management systems do represent a relative strength of Italian defence and technological industrial base on which to build. Here, an elevated level of operational and technological sovereignty should be maintained in Italy. The aforementioned systems should also be Rome's priorities to bring on the European table when it comes to work-share and cost-share of cooperative projects on missile defence – a table where an agreement is necessary to maintain and develop Italian capacities trough specialisation and interdependence. At the same time, interceptors represent a sector where Italian players made substantial progresses, and here cooperation should be sought with France in order to develop together next generation effectors. Such an approach would greatly benefit from a broader matrix of sovereign and cooperative technologies jointly developed by the Italian Ministry of Defence, with the support of the Ministry of Economic Development, and the national industry.

Fourth, the space dimension of missile defence represents a promising and growing field. As discussed in previous sections, constellations of satellites will be more and more needed to detect missiles since their launch, mainly through thermal infrared sensors, to enable fast and secure communication – also thanks to cryptography – through the nodes of the missile defence architecture, to contribute to counter measures, including but not limited to electronic warfare.[361] Space assets also have significant capacities to process data and enable C2, with a view to quantum computing.[362] Here, the EU and its member states do benefit from cooperation praxis established through decades of investments through the ESA, involving both the European Commission and national governments. Italy has played a significant role in this field since the early beginning. Building on that track record, Rome should exploit the synergy between space programmes and missile defence in a win-win logic. In particular, investments in space-based early warning capabilities, radars and communications present a cascade of military advantages and, once again, play on the relative strengths of Italy's DTIB. This would also enhance and complement the current NATO BMD, by adding a further layer and more resilience to an architecture which over-relies on the Turkey-based radar to counter the Iranian missile threat.

[360] See in this regard Section 2.

[361] See in this regard Section 7.

[362] Ibid.

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Fifth, hypersonic weapons do constitute a horizontal priority affecting NATO's IAMD, EU capability development, the space dimension of missile defence, and specific technologies ranging from radar systems to the C2 architecture. Italy should recognise that hypersonics are both the most worrying threat and the next technological frontier where all major military and space powers are investing. As such, it deserves proper investments on research and technology trough cooperative European programmes. In particular, early warning, tracking systems and seekers are relatively more at hand for Italy than other components of missile defence. In other words, they represent the technological entry point for the upper layer of BMD, through which Rome can play a significant role within both NATO's IAMD and EU defence initiatives addressing hypersonic weapons.

The continuity of Italian investments is another horizontal priority deeply influencing Italy's position on the aforementioned five key points from within. As a matter of fact, over the last decade, the industrial counterparts have suffered uncertainty over government funding for missile defence. To a certain extent, large industries have mitigated such negative factors through in-house investments on specific technologies, in order to remain competitive in the international market and be ready to work with the Italian Armed Forces once new procurement programmes will start. However, this compensating mechanism has reached its own limits when it comes to missile defence, particularly in light of the worsening of the international security environment, the hypersonic weapons breakthrough, the NATO IAMD requirements and the new dynamism of EU defence initiatives. The concrete risk is to not exploit the results achieved so far, to lose positions in the new programmes, and to jeopardise international cooperation as well as the domestic supply chain.[363] Now more than ever, certainty over Italian budgetary allocation is needed on a mid-to-long-term horizon.

Continuity is obviously not sufficient under a certain threshold of investments. While the NATO goal of 2 per cent GDP on defence spending by 2024 has been further hindered by the Covid-19 economic fall-out, getting to the average of the Alliance's European members – that is about 1.4 per cent today but is constantly moving up – should be a red line for Italy. A stagnating military budget over the next years would jeopardise operational readiness, technological sovereignty, the ability to operate within NATO and cooperate with European partners, as well as industrial capacities involving high-skilled workers on Italian territory. Within the overall spending, both the 2014 NATO Defence Investment Pledge and the 2017 PeSCo binding commitments signed by Rome commit the government on a quality allocation of resources featuring at least 20 per cent designated to equipment, including 2 per cent for research and technology activities – a commitment to be honoured every year. In that context, investments in missile defence capabilities should not only ensure the planned procurement or modernisation programmes, e.g. regarding the SAMP/T, but should also guarantee an adequate role in TWISTER

[363] Michele Nones, Paola Sartori and Andrea Aversano Stabile, "La difesa missilistica e l'Italia", cit., p. 34.

and the EDF calls contributing to develop next generation systems. Otherwise, un-sufficient and fragmented funding allocation would result in un-effective and un-efficient results.

An eight key point regards public-private partnership in this sector – as in others. The worsening of the international security environment and the acceleration of technology innovation request a timely, systematic and continuous dialogue between the military and the industry in order to address together threat assessment, requirements formulation, risks and opportunities for capability development. This is particularly important in missile defence, where most of the information are top secret and should be managed very carefully. While respecting the specific roles of each counterpart, the more and the sooner each one understands the vision of the other, the better. Indeed, the industry would be better guided by sharing the military threat assessment, and the Armed Forces would benefit by an anticipation of relevant technological trends. This implies, for example, that military officials with operational experience should have more exchanges with industry's personnel, in order to design and adjust together technological solutions. It also means more simulation, experimentation and testing in virtual and real environments, with the related investments and availability of areas.[364] Moreover, partnerships should lead to a faster and more efficient technological innovation through subsequent tranches of state-of-the-art products, harvesting the benefits of open architectures in segments where Italian industries maintain design authority. Appropriate sharing of data gathered through military operations and activities would also enable the industry to better develop Command, Control, Communication and Computer (C4) systems. As mentioned in previous sections,[365] certain limited technologies and components relevant for BMD have been already developed thanks to a variety of procurement programmes, ranging from the *Legge Navale* to the Army's digitalisation, and these elements should be exploited in a synergic way through a stronger cooperation between the industry and the Armed Forces, as well as among the latter. At the same time, public-private partnership also entails a greater, deeper and more systematic collaboration between Leonardo, MBDA and Thales Alenia Space, also considering the industrial linkages among the three companies.

Ninth, when it comes to missile defence, the Italian military needs a leap forward in terms of jointness, which so far remains unsatisfactory.[366] A fully-fledged joint operational command for IAMD should be implemented building on the basis represented by the Poggio Renatico air operations command. Sensors and effectors operated by different services should be better integrated into a more centralised C2 structure, to better leverage the variety of current and upcoming assets – including space-based ones – and further streamline the response to ever faster threats. A more robust joint command should also address the upper layer of

364 Ibid., p. 35.
365 See in this regard Section 7.
366 Ibid.

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missile defence, obviously within the NATO IAMD architecture.

Las but not least, Italy should exploit the advantages of its geographic position in order to mitigate its very disadvantages. As discussed in previous sections,[367] geography puts Italy at the front line of missile attacks from North Africa and Middle East, including from Iran and from Libya – where Scud missiles have been smuggled also to militias and/or terrorists.[368] Rome should address this risk by proposing to host further, long-range radar systems to be integrated in NATO's IAMD – which would also mitigate the aforementioned vulnerability represented by the overreliance on the Turkey-based radar. Italy is already at the forefront in terms of intelligence and surveillance of NATO's Southern neighbourhood, by hosting components of the Allied Ground System in Sigonella (Sicily), close to Niscemi, where a Mobile User Objective System (MUOS) installation is located, and this represents a solid basis on which to build in order to enhance the Italian role within NATO's IAMD.

These ten key points can only be effectively addressed by Italy through a more integrated, comprehensive and long-term approach to missile defence. Such an approach begins with the recognition of its relevance for national security, NATO collective defence and EU cooperation, as well as for the industrial and technological capacities in Italy. Various aspects have to be blended together through a top-down coordination, through inter-ministerial and joint levels and with regard to the public-private partnership. Missile defence is *per se* a highly integrated capability within NATO and in each major allied country – it can only be as such, otherwise it does not work. Metaphorically, Italy does need an equally integrated approach to missile defence in order to bring the various bits and pieces into a coherent vision able to address the threats with Allies, to build on its relative strengths, and to grasp the related cooperative opportunities. An integrated approach is traditionally difficult for Italians, but it is the only solution in this field.

Updated 5 February 2021

[367] Ibid.

[368] Michele Nones, Paola Sartori and Andrea Aversano Stabile, "La difesa missilistica e l'Italia", cit., p. 32.

List of abbreviations

A2/AD	Anti-Access/Area Denial
AAA	Anti-Aircraft Artillery
AAMDS	Aegis Ashore Missile Defence System
ABM	Anti-Ballistic Missile
ACCS	Air Command and Control System
ACS	Aegis Combat System
AESA	Active Electronically Scanned Array
AIRCOM	Allied Air Command
ALTBMD	Active Layered Theatre Ballistic Missile Defence
AMD	Air and Missile Defence
APC	Armored Personnel Carrier
ATGM	Anti-Tank Guided Missile
B-1 NT	Block 1 Nouvelle Tecnologie
BAAINBw	Bundesamt für Ausrüstung, Informationstechnik und Nutzung der Bundeswehr
BMD	Ballistic Missile Defence
BMDR	Ballistic Missile Defense Review
BMDS	Ballistic Missile Defense System
BMEWS	Ballistic Missile Early Warning System
C-G/RAM	Counter Guided/Rocket, Artillery and Mortar
C-RAM	Counter-Rocket, Artillery and Mortar
C-UAV	Counter-Unmanned Aerial Vehicle
C2	Command and Control
C2BMC	Command and Control Battle Management and Communications
C4	Command, Control, Communication and Computer
C4I	Command, Control, Communication, Computer and Intelligence
CAATSA	Countering America's Adversaries Through Sanctions Act
CAMM	Common Anti-air Modular Missile
CAMM-ER	Common Anti-air Modular Missile-Extended Range
CDP	Capability Development Plan
CEC	Cooperative Engagement Capability
CEP	Circular Error Probable
CIA	Central Intelligence Agency
CMS	Combat Management System
COA	Comando Operazioni Aeree
DACC	Deployable Air Command and Control Centre
DAE	Défense Aérienne Elargie

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DAMI	Difesa Aerea Missilistica Integrata
DARPA	Defense Advanced Research Projects Agency
DDG	Guided Missile Destroyer
DGA	Direction Générale de l'Armement
DoD	Department of Defense
DPP	Documento Programmatico Pluriennale
DPPC	Defence Policy and Planning Committee
DPRK	Democratic People's Republic of Korea
DRDO	Defence Research and Development Organisation
DS	Delivery System
DTIB	Defence Technology and Industrial Base
EABMDI	European Air and Ballistic Missile Defence Interceptor
ECoWAR	EU Collaborative Warfare Capabilities
EDA	European Defence Agency
EDF	European Defence Fund
EDIDP	European Defence Industrial Development Programme
EE-SSA-N	European Military Space Surveillance Awareness Network
EHAAP	European High Atmosphere Airship Platform
EO	Earth Observation
EPAA	European Phased Adaptive Approach
ESA	European Space Agency
EU	European Union
EURAS	European Union Radio Navigation Solution
FOB	Forward Operating Base
FREMM	Frégate Européenne Multi-Mission
FSAF	Family of Systems Surface-Air Future
G/RAM	Guided/Rocket, Artillery and Mortar
G2G	Government-to-Government
GBAD	Ground Based Air Defence
GBI	Ground-Based Interceptors
GCC	Gulf Cooperation Council
GDP	Gross Domestic Product
GMD	Ground-based Midcourse Defense
GovSatCom	Governmental Satellite Communication
GPALS	Global Protection Against Limited Strikes
HBTSS	Hypersonic and Ballistic Tracking Space Sensor
HCM	Hypersonic Cruise Missile
HCoC	Hague Code of Conduct
HGV	Hypersonic Glide Vehicle
HVP	High Visibility Project

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IAMD	Integrated Air and Missile Defence
IBCS	Integrated Air and Missile Defense Battle Command System
ICBM	Intercontinental Ballistic Missile
ICoC	International Code of Conduct
IFCN	Integrated Fire Control Network
IFF	Identification, Friend or Foe
INF	Intermediate-Range Nuclear Forces
IOC	Initial Operational Capability
IRBM	Intermediate-Range Ballistic Missile
IRGC	Iranian Revolutionary Guards Corps
ISIS	Islamic State of Iraq and Syria
ISR	Intelligence, Surveillance and Reconnaissance
ISRO	Indian Space Research Organisation
JCPOA	Joint Comprehensive Plan of Action
KAMD	Korean Air and Missile Defense
KFOR	Kosovo Force
kg	kilogramme
km	kilometre
km/s	kilometre per second
kmph	kilometre per hour
KMPR	Korean Massive Punishment and Response
KPASRF	Korean People's Army Strategic Rocket Force
kt	kiloton
L-SAM	Long-range Surface-to-Air Missile
LHD	Landing Helicopter Dock
LoI	Letter of Intent
LORA	Long Range Attack
LORAN	Long Range Navigation
LRDR	Long-Range Discrimination Radar
LTF	Land Task Force
m	metre
M-SAM	Medium Surface-to-Air Missile
MAD	Mutual Assured Destruction
MALE	Medium Altitude Long Endurance
MANPADS	Man Portable Air Defense Systems
MaRV	Manoeuvrable Re-entry Vehicle
MDA	Missile Defense Agency
MDC	Missile Defence Centre
MDR	Missile Defence Review
MEADS	Medium Extended Air Defense System

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MIC4AD	Multi-Level Integrated Command, Control and Communications Air Defence
MIRV	Multiple Independently targetable Re-entry Vehicle
ML	Machine Learning
MoD	Ministry of Defence
MRAD	Medium-Range Air Defence
MRBM	Medium-Range Ballistic Missile
MSE	Missile Segment Enhancement
Mt	megaton
MTCR	Missile Technology Control Regime
MUOS	Mobile User Objective System
NASAMS	National Advanced Surface to Air Missile System
NATO	North Atlantic Treaty Organization
NCIA	NATO Communications and Information Agency
NDPP	NATO Defence Planning Process
NDSA	National Defense Space Architecture
NG	New Generation
NGO	Non-Governmental Organisation
NIAG	NATO Industrial Advisory Group
NIFC-CA	Naval Integrated Fire Control-Counter Air
NPG	Nuclear Planning Group
OCCAR	Organisation Conjointe de Coopération en matière d'Armement
OEG	Operational Experts Group
ONERA	Office National d'Études et de Recherches Aérospatiales
PAAMS	Principal Anti Air Missile System
PAC-2	Patriot Advanced Capability-2
PAC-3	Patriot Advanced Capability-3
PAC-3 CRI	Patriot Advanced Capability-3 Cost-Reduction Initiative
PAC-3 MSE	Patriot Advanced Capability-3 Missile Segment Enhancement
PeSCo	Permanent Structure Cooperation
PGM	Precision-Guided Munition
PGZ	Polska Grupa Zbrojeniowa
PLARF	Peoples Liberation Army Rocket Forces
PLN	Pre-Launch Notification
PNT	Position Navigation and Timing
PSI	Proliferation Security Initiative
R&D	Research and Development
RAF	Royal Air Force
RDD	Radiological Dispersal Device
RGPWS	Hypersonic Defense Regional Glide Phase Weapon System

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ROK	Republic of Korea
RVSN	Raketnye vojska strategičeskogo naznačenija
SAAM	Surface Anti Air Missile
SAAM/ESD	Surface Anti Air Missile/Extended Self Defence
SAAM-IT	Surface Anti Air Missile-IT
SACEUR	Supreme Allied Commander Europe
SALT I	Strategic Arms Limitation Talks I
SAM	Surface-to-Air Missile
SAMP/T	Surface-to-Air Missile Platform/Terrain
SCC	Standing Consultative Commission
SDI	Strategic Defence Initiative
SDR	Strategic Defence Review
SDSR	Strategic Defence and Security Review
SEW	Shared Early Warning
SHORAD	Short-Range Air Defence
SLBM	Submarine-Launched Ballistic Missile
SM-2	Standard Missile-2
SM-3	Standard Missile-3
SM-3 IB	Standard Missile-3 Block IB
SM-3 IB TU	Standard Missile-3 Block IB Threat Upgrade
SM-3 IIA	Standard Missile-3 Block IIA
SM-6	Standard Missile-6
SORT	Strategic Offensive Reduction Treaty
SPAAG	Self-Propelled Anti-Aircraft Gun
SPIRALE	Système Préparatoire Infra-Rouge pour l'ALErte
SRBM	Short-Range Ballistic Missile
SSA	Space Situational Awareness
SSBN	Ballistic Missile Submarine
SST	Space Surveillance and Tracking
START	Strategic Arms Reduction Treaty
T&CB	Transparency and Confidence-Building
TEL	Transporter-Erector-Launcher
TEWA	Threat Evaluation and Weapon Assignment
THAAD	Terminal High Altitude Area Defense
TLP	Très Longue Portée
TLVS	Taktisches Luftverteidigungssystem
TWISTER	Timely Warning and Interception with Space-based Theater Surveillance
UAS	Unmanned Aerial System
UAV	Unmanned Aerial Vehicle

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UEWR	Upgraded Early Warning Radars
UHF	Ultra High Frequency
UK	United Kingdom
UN	United Nations
UNIFIL	United Nations Interim Force in Lebanon
US	United States
USSR	Union of Soviet Socialist Republics [Soviet Union]
VJTF	Very High Readiness Joint Task Force
VLS	Vertical Launching System
VSHORAD	Very Short-Range Air Defence
WMD	Weapons of Mass Destruction

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