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INTEGRATED AIR AND MISSILE DEFENSE (IAMD) IN EUROPE : COMPLEXITY, CONSENSUS AND NEW CHALLENGES

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GLOSSARY

3AF: Association Aéronautique et Astronautique de France
ABT: Air Breathing Target
ACCS: Air Command and Control System
AESA: Active Electronically Scanned Array
ALTBMD: Active layered theater ballistic missile defense
ARS: ARS is a Control Centre in charge of managing 3 capacities: Air Control Centre – Recognized Air Picture (RAP) production centre – Sensor Fusion Post
BMD: Ballistic Missile Defense
BMDOC: BMD Operation Centre
C2: Command & Control
C4I: Command, Control, Communications, Computers and Intelligence
CEAS: Council of European Aerospace Societies
CEC: Cooperative Engagement Concept
EPAA: European Phased Active Approach
EWC: Early Warning Control
FMS: Foreign Military Sales
FREMM: Frégate Multi Missions
FTI: Frégate de Taille Intermédiaire
GBI : Ground-Based Interceptor
GMD: Ground-based Midcourse Defense
GMDS: GMD System
HMI: Human Machine Interface
IAMD: Integrated Air and Missile Defense
IRBM: Intermediate Range Ballistic Missile
InCa: Initial Capability
MEADS: Medium Extended Air Defense System
MFR: Multi Function Radar
MRBM: Medium Range Ballistic Missile
NATO: North Atlantic Treaty Organization
NATINAMDS: NATO Integrated Air Missile Defense System
NIAG: NATO Industry Advisory Group
PAAMS: Principal Anti Air Missile System
SAAM: Surface-to-Air Anti-Missile
SAMP/T: Surface-to-Air Moyenne Portée/Terrestre (French-Italian Surface-to-Air Defense Missile System)
SMART-L: Signal Multi beam Acquisition Radar for Tracking-L band
TLP: Très Longue Portée
TLVS : Taktische Luftverteidigungsystem (German MEADS)
TMD: Theatre Missile Defense
TBM : Tactical Ballistic Missile

CONTENTS

GLOBAL DESIGN AND ARTICLES COORDINATION: LUC DINI (3AF)
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3AF PRESIDENT'S MESSAGE

3AF President Michel Scheller

For 14 years, the 3AF Missile Defense Conference has allowed to share and discuss missile defense challenges around the globe, reinforced ties and explored new ideas to promote missile defense advances. It was an initiative from 3AF, France, proposed to all of our partners, sponsors and attendees from all Europe, American and Asian continents and from Israel.
The 3AF Missile Defense International conference "challenges in Europe" was strongly supported indeed and led us to think of an evolution to better adapt the debate and the content to the current international environment.
As an integrated air and missile defense (IAMD) becomes an obvious solution to meet today's priorities, it seems therefore appropriate that our Missile Defense challenges should now be considered within the wider frame of IAMD, that is why we decided to extend our Missile Defense Conference spectrum to Air Defense and rename it "3AF Integrated Air and Missile Defense conference".
This 12th 3AF Integrated Air and Missile Defense conference takes place in Stockholm, Sweden 27-29 June 2017. It is built on the previous editions to address both the BMD and IAMD capability developments in and outside Europe. This document "IAMD in Europe: complexity, consensus and New Challenges" gives both a restrospective on recent IAMD events and a vision to the future of IAMD, pending on different factors which are expressed by the experts.

INTRODUCTION

By French Air Force General Jean-Paul Paloméros

French Air Force General Jean-Paul Paloméros (Ret.)

Former NATO Supreme Allied Commander for Transformation (SACT), 2012-2015

Former French Air Force Chief of Staff, 2009-2012

THE INNOVATIVE, INTERACTIVE, INTEGRATED AIR AND MISSILE DEFENSE

"*The future IAMD environment will be characterized by a full spectrum of air and missile threats—ballistic missiles, air-breathing threats (cruise missiles, aircraft, UAS [unmanned aerial systems]), long-range rockets, artillery, and mortars—all utilizing a range of advanced capabilities—stealth, electronic attack, manoeuvring re-entry vehicles, decoys, and advanced terminal seekers with precision targeting.*"
This statement made by the former Chairman of the Joint chiefs of staff General Martin E. Dempsey appeared in a founding document released by the Pentagon in 2013, the «Joint Integrated Air and Missile Defense: Vision 2020». One couldn't better describe the complexity, the uncertainties and the challenges that Allied Forces have to face to best assume populations and territories' protection, keep their freedom of action and maintain operational superiority. While in the past it was possible to conceive and develop dedicated assets, weapons and command and control systems to take care of specific air or missile threats, now days it's crucial to look at the new operational environment with a comprehensive vision and a new approach to give IAMD its full efficiency.
For the foreseeable future, on the one hand, the resurgence of power states investing massively in their defense will increase the sophistication and the quantity of their offen-

sive inventory. Not only they will be able to deploy new generation ballistic missiles, advanced cruise missiles, long range precision weapons but they will certainly increase their efforts to better connect those assets and mix them with massive employment of strategic and tactical UAVs able to saturate the operating space. We can expect as well that those potential opponents will use extensively cyberspace operations to attack allied networks and bring confusion in their Command and Control (C2) chains in order to hamper decision making process.
On the other hand, on diverse operating areas, and even at home, our defense and security forces will have to face even more asymmetric threats as their opponents will be able to use even more new technologies to their benefit. They will increase the lethality of some rudimentary weapons such as Improvised Explosive Devices (IED) while developing their skills and capability in using swarms of tactical UAVS to saturate allied command and control networks and defensive capacities.

According to the pledge made at the Wales summit we can expect to see growing defense efforts in NATO countries to meet the 2% GDP target with the minimum of 20% defense budgets dedicated to major investment.
However, it's likely that increasing budget will not be enough to cope with the new strategic environment as described earlier, Allied will have to keep on developing a smarter approach to develop effective their IAMD capabilities.
First and foremost, they should improve their command and control networks interoperability and resilience from the strategic down to the tactical level. In that field they can for instance capitalize on the progress of cloud computing to be able to recover from major cyber attacks and reconfigure instantly their C2 networks in order to keep the indispensable seamless operational chain. To better adapt to the threat and adjust their defensive posture and the use of appropriate defensive systems, Allied should as well capitalize on the unique power brought by Artificial Intelligence (AI) and deep learning. In collecting in real time the huge amounts of data coming from the battlefield through multiple ISR collection assets, they could feed AI systems which would improve the understanding of adversaries operational and tactical patterns and adapt in near real time the employment of best suited assets.
Those breakthrough innovations should be beneficial as well to IAMD offensive capabilities.
Allied should therefore focus their efforts on offensive cyber measures able to disrupt adversaries' C2. They should as well improve and diversify their offensive weapons inventory to be able to tailor them to the desired operational effect thus reducing collateral damage risks and maximizing the impact on selected target.

DELIVERING DIGITAL TRANSFORMATION FOR AIR DEFENSE AND IAMD

By Thomas Got, VP Managing Director for Thales's air operations and weapon systems activities (AOW)


Thomas Got

What the world would look like without the Internet? Its pervasiveness does more than just connect people and organization; it also connects things, making global information-sharing transformational for society. Change is now the norm for businesses in this environment and Thales is no exception. As a company, Thales is both driving new digital transformations for customers and also undergoing a cultural transformation that encourages employee innovation and entrepreneurialism.

The modern threat environment for militaries is complex and new disruptive technologies present both opportunities and challenges that must be met. At Thales, we are leveraging these disruptors to enhance our product, making it more flexible and adaptive to today's digital environment.

In the era of digital transformation for Air and Missile Defense, our military users benefit from access to real-time data – even in remote areas – for improved situational awareness and powerful, flexible networks (sensors, weapons, tactical data link, data fusion) that maintain operational effectiveness and security. For users across the NATO Air Operations command chain, devices that have an increased level of autonomy will help create more responsive, effective and informed tactical decisions. These problems are in the heart of the future Air C4I capability.

Today, Thales has a leading position delivering data centric defense solutions that provide cyber defense, threat detec-

tion and networked capabilities to help improve mission effectiveness around the globe. We are working through 4 axes: (big) data, connectivity, Artificial Intelligence and Cyber defense.
The most symbolic programme of Thales is doubtless the ACCS program, which is one of the most advanced systems in the world for military air operations developed and fielded through a longstanding cooperation between Thales and Raytheon. ACCS, as an integrated air and missile defense system, provides full coverage and protection for all NATO European populations, territory and forces against the increasing threats as aircrafts, cruise and ballistic missiles. ACCS is in an operational phase today: the deployment began in Italy and should be completely realized for all the nations before four-five years. ACCS TMD1 addressing Theatre Missile Defense in an IAMD environment has been declared operational as soon as in 2012 for the Chicago summit as an interim capability and again in 2016 at the Warsaw summit as the IOC (Initial Operational Capability).

In the future, as the military connects more and more assets to create advanced tactical pictures, Thales and its partners will be ready with the technical knowledge and sophisticated capabilities to support them. Thales with Raytheon, supplies NATO with Air C4I systems and we are present in all the Alliance future programs for which we have even a mission to federate the European defense industries and to cooperate with the biggest American defense industries.

Thanks to the evolution of the connectivity of the systems due to fast communications with low latency, and to the eve of Artificial Intelligence to manage distributed systems in real-time, Thales also has a vision for the evolution of the surface air weapon systems, which operate in real-time far below one second, while being interlaced by tactical data links with the Air C4 and the surveillance network. Penetrating the world of these weapons systems where the detection, the safe identification, the engagement and the destruction are a matter of seconds, we see new technologies like digital AESA multifunction radars, fast communication, and distributed artificial intelligence as keys to build new and smart Fire Control networks (FCnet). These networks will allow to improve the fire control systems effectiveness, flexibility and resilience by distributing, sharing, and focusing together their intelligence, energy and resources timely (below 1 s) and in space in a smart and collective manner. By doing so, we will build clusters of fire control systems, hardened and reconfigurable, to maintain long range detection and tracking, high reactivity and accuracy, fast and multiple engagements to counter the effects of multiple threat that will use saturation, stealth, jamming, high agility and cyber effects.
Among IAMD weapon systems, the SAMP/T is the single 100% European, from conception to realization. It has been developed and produced by Thales (responsible, design authority for the Firing Unit fitted with the ARABEL MFR radar) and by MBDA (responsible for the Aster missile and the launchers) through the EUROSAM consortium, in cooperation with France and Italy. This system is already remarkable due to its Fire Control system and missile performance. It received the International Pioneer Technology Award from the international AIAA BMD conference committee and from the US Missile Defense Agency in 2015 for its ATBM operational live firing with a direct hit, coordinated with NATO and US BMD systems. Thales also currently conducts the evolution of the SAMP/T B1NT fire control system with an open architecture to enhance the ATBM and the logistics performance. Furthermore, Thales develops the digital AESA MFR radar antenna that will be applied to the Ground Fire radar familly, for SAMP/T, together with an improved Fire Control connectivity. This evolution will provide ever better outstanding performances.

All these elements are quite essential for the future high performance weapon systems we will have to interlink tightly with the AirC4I to ensure both effective and secured engagements against a wide diversity of threats in the airspace where a high density of air operations will have to be conducted. This is key for the national air sovereignty of each nation (our customers) and for the interoperability of national air systems with others.
This is where Thales can join its long experience of integrated air systems and innovation to envision, shape and transform the airspace connected to the cyberspace and crossed by the electromagnetic waves of communications, sensors, jammers and tomorrow, of electromagnetic weapons systems.
Thales plays a very active role to promote this vision and approach towards our users and partners.

We have a great confidence into our future and our contribution to promote and federate innovative solutions together with our partners.

INTEGRATED AIR AND MISSILE DEFENSE (IAMD) IN EUROPE: COMPLEXITY, CONSENSUS AND NEW CHALLENGES

By Luc Dini, Co-Chairman of the 3AF Integrated Air and Missile Defense Conference

GENERAL BACKGROUND

Air defense and anti-ballistic missile defense have been subjects of projects and debates within NATO for more than 10 years. They regularly bring about adjustments to the evolution of the strategic context of threats. The reality of air threats and of short range ballistic missiles is today indisputably present in Europe's exterior zones and still at the door of NATO territories, while the combination of air defense systems and air operations adds to the overall complexity. Moreover the security of the airspace is a true sovereignty issue in this period of crisis and tension for any nation, far beyond the BMD defense debate. While NATO is equipped with air defense command systems which can be extended to missile defense, research into a consensus on integrated air & missile defense seems probable inside NATO and Europe. It is attainable if there are equal and measured contributions from the USA and Europe, with participation from European industry in projects that Europe has already invested in. In a context of a budgetary discipline but also of security risks, transatlantic and European industry can and must provide solutions for the evolution of command systems and reinforced interoperability of defense systems. For example, concepts of networking sensors and weapons systems could be envisaged in the short/medium term as a factor of improvement of the interoperability between systems but also cooperation between the industries. The digital transformation of the C4I but also of all the engagement chain down to the fire control systems will provide the opportunity for an ever better interoperability and cooperation. IAMD should be also a theme of common understanding with Russia who has contested the deployment of BMD long range systems in Europe, while enhancing its own aerospace defense systems to deny any attempt to enter their airspace and protect their troops.

PERCEPTION OF THREATS AND PRIORITY BALANCE BETWEEN THEATRE AND TERRITORIAL DEFENSE

In view of the generalization of air and missile threats Europeans must put their differences aside in order to find a consensus on an Integrated Air and Missile Defense (IAMD) all whilst preserving the sovereignty of airspaces and of national territories which is a priority for any nation (not only in NATO), especially in a time of crisis and uncertainty. At the same time, the command and control of NATO Air component allows for the conducting of coordinated air operations interfacing with national ACCS air control centers (ARS).

How do you defend yourself when facing threats which we call 'Air-Breathing propulsion or Air-Breathing' as well as ballistic threats, which together form, what we call in Missile Defense Jargon, 'a dual threat'? Furthermore, how do you preserve or even reinforce the balance between collective and national contributions to NATO and the role played by the European industry, all whilst facing budgetary pressures which weigh on European defense budgets? How do you assure that an integrated NATO command with a consultation process between nations for the planning and the rules of engagement of long range BMD weapons systems against threats which fly over Europe? How do you ensure the security of your airspace in Europe, on the NATO side as on the Russian side, by enhancing capacity while maintaining a balance and dialog? These are the many challenges to take up!

The development of the ALTBMD (Active Layered Ballistic Missile Defense) target architecture for NATO Theatre Missile Defense, started gradually in 2005, with the first operational capability called 'InCa' an Interim Capability which was declared operational in 2011, then became a capability for an interim Ballistic Missile Defense for territory (iBMD) declared operational at the 2012 Chicago Summit. Its objective was the gradual integration of a missile defense architecture composed of various layers of defense (high and low altitude) for protecting troops in operation as well as sites of vital importance against a dual threat on theatres of operation. This dual threat is made up of intermediate range ballistic missiles (range of up to 3000 km) and 'Air-Breathing' threats such as cruise missiles or fighter planes.

ABOUT ANTI-ICBM DEFENSE

Nevertheless, since the start of the 2000s studies on defense of territories and of population have equally been pushed by NATO in order to fight against an emerging ballistic threat, the long range ICBM type missile. Although there is an aim for potential spreading in certain countries, this ICBM threat was not seen as a priority in Europe, whereas it is considered more probable in the USA. To this end, the USA have deployed a Ground-based Midcourse Defense system 'GMD' to counter this threat, based mainly on the long range Ground Based Interceptors (GBI) across 2 American sites. Without a global consensus, either on the

spectrum of the threat or the priorities in terms of costs and budget, there has not been a willingness to invest in a defense system which is judged to be very expensive for anti-'ICBM' defense of Europe. The '3rd missile defense site in Europe' project, supposed to complement the two American sites, was an example of this difference in the assessment of priorities in terms of threats and the way to protect. Also, the American project was almost uniquely focused on the America's homeland protection by a third advanced site in Europe, whereas the coverage of Europe remains partial in terms of ICBMs, considered as a non-priority threat by Europeans, then finally by the USA. The project was therefore abandoned in 2009.

However, the BMD capacity against ICBMs remains a priority for the USA who maintains and enhances its Ground BMD system by adding a new discrimination radar in Alaska and looking at the option for deploying a third GBI site, due to the increasing risks of North Korea nuclear proliferation. The US tense relationship with Russia, including mutual accusations of violation of the INF treaty, might raise some proposal to enhance regional BMD in Europe or BMD in the US. However, as Mr Franck Rose explained in his article[1], different actions could be considered as a response to the deployment of ground based nuclear cruise missiles by Russia, while not recommending the extension of BMD systems in Europe against Russia, but enhancing the air defense against cruise missiles. The European regional Ballistic Missile defense should remain, as explained by the US and NATO, not a defense against Russian deterrence. In parallel, looking at the US BMD evolution, Dr Roberts reviews (see insert 1), options for the US Missile Defeat Review like enhancing the continental US BMD systems not only against Iran or North Korea, but possibly also against Russia. This is a different perspective, since the defense of the US continent against Russia was never considered again after the cold war. Moreover defending a large territory and population against a limited strike from a rogue country is a very different mission from defending it against a sophisticated nation capable of operating very effective ICBMs. As Dr Robert says, the viability of such a territorial missile defense over the longer term is an open question. The Russians on their side modernized not only their ICBMs capacity, but also their BMD and IAMD systems. However, they never considered the defense of their population and territory as a realistic mission against a sophisticated ICBM force. They focused on the defense of their strategic assets.

THE US EPAA PROJECT

The political approach has changed radically with the US regional defense project 'European Phased Adaptive Approach' (EPAA) proposed by the Obama administration. This was a new start for the cooperation on missile defense in Europe based on the upper layer of the ALTBMD; thus a synergy appeared possible between the American systems - Aegis Frigate fitted with SM3 missiles, made also in a land version, Aegis 'ashore' - (Figure 1), the NATO and American Command Centres and the European IAMD (integrated air and missile defense) systems. The US EPAA also confirmed the deployment of American ground based ballistic missile defense systems combined with high altitude systems (Aegis ashore missile SM3) and dual low altitude effectors such as the Patriot (Figure 2), American or European (German and Dutch) systems or the Franco-Italian SAMP/T (Figure 3). In fact, it is important to ensure the Defense of sites against more conventional or short range ballistic threats which target the most exposed Alliance Zones. For example, the SAMP/T was designed at

Figure 1: The Aegis system.

Figure 1.1: Radar SPY-1 of the Aegis system which operates in S band, with SM3 Firing

Figure 1.2: Radar AN-TPY2 of the Thaad in X band.

Figure 1.3: Aegis system ashore

The 'AEGIS' is a combat system mounted on American destroyers which allows for the implementation of the exo-atmospheric SM3 missile (see Figure 1.1) with the AN-TPY2, conceived as a firing control radar of the Thaad system, which is dedicated to anti-ballistic missile, but also used in an alert radar mode in an advanced position (FBR), in order to allow a pursuit of ballistic missiles and allow for an engagement of the SM3 missile in a 'launch on remote' or 'engagement on remote' mode before the tracking of the assailant missile by the SPY 1 Fire control radar of the AEGIS.

1. Mr Franck Rose (former under secretary for Arms control) and Sir Alexander Vershbow (former deputy Secretary General at NATO) published a note "Russia violated our nuclear arms treaty. Here is how we respond http://thehill.com/blogs/pundits-blog/foreign-policy/329943-russia-violated-our-nuclear-arms-treaty-heres-how-we. This note explains the position of the writers related to the Russian development of a ground based launch nuclear cruise missile with a capacity between 500 and 5500 km. Different options of response are presented. However, the transformation of the BMD in Europe against Russia is not a recommendation.

Insert 1

THE 2017 REVIEW OF U.S. MISSILE DEFENSE POLICY AND POSTURE- Dr Brad Roberts

Brad Roberts is director of the Center for Global Security Research at Lawrence Livermore National Laboratory. From 2009 to 2013 he served as U.S. Deputy Assistant Secretary of Defense for Nuclear and Missile Defense Policy and in this capacity was co-director of the Obama Administration's Ballistic Missile Defense Review. The views expressed here are his personal views. This essay summarizes arguments made in Roberts, "Anticipating the 2017 Review of U.S. Missile Defense Policy and Posture," in Thomas Karako, ed., Missile Defense and Defeat: Considerations for the New Policy Review (Washington, D.C.: Center for Strategic and International Studies, 2017).

As one of his first acts in January 2017, President Trump directed the Department of Defense to conduct a set of six reviews of defense policy and posture, one of which is a ballistic missile defense review. This follows congressional guidance to conduct a review that would look broadly at the challenges of defeating enemy missiles.

The review is likely to encompass the following main elements. It will begin with an intelligence-informed review of the threat environment. This will look both backwards and forwards—to assess developments since 2009 and predict developments over the next decade or so. It is likely to characterize a threat that has become more complex and diverse, including the rising salience of the cruise missile threat. The Russian missile threat to NATO stands out as a major new development since 2009.

This review will then likely assess the 2017 Program of Record for the acquisition of additional and new missile defenses. That program reflects Obama-era decisions to flesh out the homeland and regional missile defense postures by completing the deployment of 44 ground-based interceptors and continuing to ramp up deployed regional forces. How to hedge against the possibility of future threat growth will be a key consideration, leading to further discussion of an additional missile field in the United States.

The third main building block will be a review of the budget context. Missile defense budgets have gone down over the last decade—by 14 percent—and this has had a major impact on investments for advanced capabilities. Budget relief is promised. But it may prove difficult to deliver.

The fourth main building block will be a review of the political context. The bipartisan consensus in favor of missile defense has been key to continued progress over the last two decades. But it is neither broad nor deep. It has been built around a commitment to protection of the homeland from limited strikes by countries such as North Korea. The Republican majority recently revised the relevant law, striking the term "limited" and committing the United States to seek a robust, multi-layered defense of the homeland. Whether this will be politically viable over the longer term is an open question.

The fifth main building block will be a review of policy. The main priorities set out in the Ballistic Missile Defense Review Report of 2010 will be reviewed and debated. Although they enjoyed broad bipartisan support at the start of the Obama administration, every new administration needs to put its imprint on inherited agendas, in part by setting out its own policy priorities. But there has been a good deal more continuity in national policy than change over the last two decades, despite major changes in the White House, and more continuity can be expected, along with some changes.

On homeland defense, the key issues are likely to be the following. First, how far away from the "limited" criterion can the United States practically go with available funding and technologies? Should the Trump administration seek protection of the American homeland from strikes by Russia and China (a position rejected by the three prior administrations, on the argument that doing so would undermine strategic stability with them and in any case would not be viable)? And if the administration decides not to seek such protection, will it continue the efforts of prior administrations to assure Moscow and Beijing of U.S. strategic intent (efforts that have gone largely unrewarded)?

The second key homeland defense issue will be whether and how to retain the 2009 commitment to maintain the currently "advantageous position" vis-à-vis North Korea and Iran. As one or both develop and deploy long-range missiles, the current ratio of approximately 40 interceptors to zero ICBMs will begin to shift. If North Korea and/or Iran launches into a build-up of such systems, what can and should the United States do to stay ahead? And how far ahead should it want to stay? And if it pursues a robust BMD buildup, what can the United States expect from China (and Russia) in response?

On regional defense, the central question will be how to build on the phased, adaptive approach in Europe, Northeast Asia, and the Persian Gulf. In Europe, phase 3 of EPAA will be concluded within a year. How should the European missile defense posture continue to evolve, if at all? Is territorial defense against threats from the Middle East "enough" or does NATO also require some theater missile defense protection from new ballistic and cruise missile threats from Russia? Of course this is a question that cannot be answered without the participation of NATO allies. In Northeast Asia, major questions exist about how to strengthen trilateral cooperation (among the United States and its two allies, Japan and South Korea) and about the future role of the advanced missile defense interceptor emerging soon from joint U.S.-Japan development. Questions about where and how to deploy that interceptor are directly connected to difficult questions about what role the regional missile defense should play vis-à-vis China. These questions too cannot be answered without the participation of U.S. allies.

These five building blocks will come together over the course of 2017, leading to a report sometime in autumn 2017 or winter 2018 setting out the administration's policy priorities and its decisions about how to further develop U.S. and allied missile defenses. There is good reason to expect a lot of continuity relative to the 2010 report, with its twin commitments to homeland and regional defense, to cooperation with allies, and to strategic stability.

But there is also a strong case to expect more change than continuity. Within the Republican Party, there is a significant body of opinion to move away from the commitment to the "limited" criterion for homeland defense. Moreover, there is a clear need to adapt the regional missile defense strategies, policies, and architectures to the new challenges posed by Russia and China. But making big changes to U.S. missile defense strategy, policy, and capabilities is easier said than done. Money is tight. Technology is even more constraining. Relations with allies can be critical enablers of U.S. strategy and policy—but also critical constraints. Moreover, the executive branch is only one actor on this topic. The Congress has strong views on these questions and whatever its policy preferences, the Trump administration can only secure requested funding through a process of sustained consultations with congressional stakeholders.

Figure 2: The Patriot system.

Figure 2.1: Fire Control radar of the Patriot system.

Figure 2.2: Command & Control shelter of the system.

The Patriot system is a system of medium range low altitude ground based air and antimissile defense, conceived mainly for the fight against short range ballistic missiles. Existing since the 80s, it is now in a PAC3 version, equipped with sectorial multi-function radar in C band (possibly with lateral antennae) and must be equipped with an improved missile called MSE. The PATRIOT system is 100% American, provided by Raytheon and Lockheed Martin.

Figure 3: The ground SAMP/T system and the naval versions.

Figure 3.1: Multi-Function Radar ARABEL (Firing Unit)
Figure 3.2: Module of engagement (Firing Unit)
Figure 3.3: Module launcher
Figure 3.4: Firing of the Aster from a module launcher

The Franco-Italian weapons system SAMP/T (Surface-Air Moyenne Portée/Terrestre), by conception totally dual, responds simultaneously to conventional air threats and short range ballistic threats.
The principles of SAMP/T are notably the defense of a 360° zone, its mobility and its aero-transportability in exterior theatres of operation. From conception to realization 100% European, it is developed and produced by Thales (responsible, design authority for the Firing Unit) and by MBDA (responsible for the Aster missile and the launchers) through the EUROSAM consortium, in cooperation with France and Italy. The SAMP/T system is in service in these two countries, providing a national contribution to the NATO anti-ballistic missile programme.

A SAMP/T battery comprises a firing control unit (Arabel multi-function radar) (Figure 3.1) and an engagement's module (Figure 3.2) and 3 to 4 launchers (Figure 3.3) armed with 8 Aster 30 B1 (Figure 3.4). The SAMP/T is in operational service in the French and Italian Air Forces and continues to evolve (see page 17). It was fired in 2013 with direct impact against a SCUD target coordinating with NATO via 'Liaison 16': a success for which it received the Technology Pioneer Award of 2015 (see page 18). The SAMP/T equipped with the Aster 30 B1 missile responds to the need of current and future anti-air missions. At the end of 2015 a contract was formed between EUROSAM, Thales and MBDA for the development of the SAMP/T B1NT armed with the Aster 30 B1NT (equipped with a Ka band seeker for more precision) and a new firing unit to improve the performance and adaptation of the system to new operational constraints, one of which being the ballistic threat at a range of 1000km.
This firing unit system will benefit from the open software architecture, innovative and evolutive, protected against cyber attacks, proposed by Thales (Fire Unit design authority), and already applied to the Charles de Gaulle aircraft carrier (see Figure 4.1 and comments). The B1NT contract was extended to the French-Italian cooperation at the end of 2016, involving then MBDA–Italy under Thales design authority for the fire control unit. The SAMP/T is armed with a 360° capacity against supersonic diving and skimming missiles resulting in the conception of medium range ground to air family at the time ground and naval (see figure 4.1) benefiting from a high performing firing capacity against very fast targets including ballistics.

Further improvements of the SAMP/T called SAMP/T NG by the industry with fire control system and sensors enhancements are also under analysis (see page 17).

the start, with its Arabel Fire-Control radar and the Aster 30 missile, for a 360° protection against cruise missiles and sea-skimmer missiles, including an equivalent naval version - SAAM system and PAAMS - Figure 4). The US EPAA project also allowed initially for delaying the situation with the Russians on the question of territorial anti-missile Defense, while cooperation already existed between Russia and NATO on the interoperability of theatre anti-missile systems.

The 'New Start Treaty' opens a new approach

By proposing new discussions on the 'New Start Treaty' agreement, and by opening a dialogue on missile Defense by clearly separating field of intercontinental Defense with medium range Defense, derived from Theatre Defense , the Obama administration undertook an approach to dialog which would set the tone of the 2010 NATO summit in Lisbon, following the NATO-Russia Summit. It is during this

Figure 4: Other European Naval and Ground systems.

Figure 4.1: SAAM system with the MFR ARABEL radar (band X) equipped onto the CDG aircraft carrier and the Sawari 2 frigates.
Figure 4.2: LRR / S1850 radar (Smart-L family in L band); an air surveillance radar on the Horizon frigates (Franco-Italian), T45 (UK), but also German, Danish and Dutch frigates…
Figure 4.3: MFR EMPAR radar of the French and Italian Horizon frigates (PAAMS System) in C band. Studies of improvement of this radar family with new technologies are currently conducted.
Figure 4.4: MFR SAMPSON radar of the T45 frigates in S band.
Figure 4.5: MFR Herakles radar (Figure 4.5a) in S band on the FREMM French frigates participating in maritime IAMD tests At Sea Demo 2015 (Figure 4.5b) for a detection mission and autonomous antiballistic missile pursuit compatible with its air defense mission.
Figure 4.6: X band MFCR radar of the demonstrator of the MEADS system, destined for the future German TLVS system.

The naval versions of the medium range weapons systems equipped with Aster missiles are adapted to different missions and naval platforms for France, Italy and Great Britain and non-European marines (KSA, Morrocco, Singapore). The systems are all armed with Aster 15 and/or Aster 30 missiles with the SAAM firing unit (Aircraft Carrier Charles de Gaulle (FR), Frigate Sawari2 (KSA) with the multifunction ARABEL radar in band X (Figure 4.1), PAAMS for the Horizon Frigates (FR,IT) with surveillance radars LRR S1850/(of the smart-L in L band) (Figure 4.2), the MFR EMPAR radar in band C (Figure 4.3), and T45 with the S1850 radar and the MFR SAMPSON radar in band S (Figure 4.4). The FREMM frigates, armed also with the Aster missile, are equipped with the MFR Herakles radar (Figure 4.5) or EMPAR already used in Italy.
We see that Europe contributes in multiple ways by its technologies to a radar capacity with multi-function and multi frequency firing units, which includes also X band radars like the MFCR radar demonstrator of MEADS, destined for the future German TLVS system (Figure 4.6) and the Dannish Weibel radar in X band.

The SAAM system ensures the protection of Charles de Gaulle Aircraft carrier, in coordination with the other sensors and effectors on board as part of the combat system, against all type of air breathing threat including all kind of aircraft and missiles. Thales provides the firing unit system which includes a fire control centre, the naval version of the ARABEL Multifunction radar (like the ground version on SAMP/T) and operates the firing of the MBDA Aster missiles in security.
This system is installed on the PA CDG since 2001. Thales was notified by OCCAR in 2014 of a contract for renovation of a sub assembly of this fire control unit. The objective of the contract is to equip the system of a new computer unit fitted with a new software cyber secured based on an open architecture. This software architecture is a modular design which software components managing the fire control system and its interfaces are as many undependant applications. The architecture is therefore based on a database oriented architecture and on the associated data distribution service to run the system and allow a easy further evolution.

summit that NATO decided to seriously explore the possibility of a territorial missile Defense and cooperation with Russia, which in itself demonstrates that the proliferation of ballistic missiles is not limited to short range ballistic missiles (although they are the most common). MR Franck Rose also admits in his article, although he points out Russia's alleged violation of INF treaty, that Russia still complies with New Start treaty ceilings and verifications.

The US EPAA Evolution

The US EPAA was therefore a new approach because it changed the priority on the threat, taking into account the MRBMs – Medium Range Ballistic Missiles - (Phases 1 and 2), then the IRBMs – Intermediate Range Ballistic Missiles - (Phase 3), considering ICBMs – Inter Continental Ballistic Missiles - as a secondary threat (Phase 4 finally abandoned) facing Europe and NATO (according to the US BMD review at the start of 2009). It prescribes as well a mobile defense, reconfigurable, like Theatre Missile Defense, mainly naval. The principal decisions of Lisbon were reinforced in Chicago in 2012 with the declaration of the operational character of the NATO interim ballistic missile Defense capacity 'iBMD capability', based mainly on the US Aegis effectors, partially covering Europe. This declaration was accompanied by the decision to proceed with the BMD expansion of the ALTBMD in order to cover the complete European territory of NATO. This defense was placed under NATO control at its BMDOC – Ballistic Missile Defense Operation Centre - in Ramstein, Germany. The final objective was therefore to protect all the territories, populations and troops of member nations against ballistic missiles in the European territory of the Atlantic Alliance , all whilst reaffirming that BMD complements NATO's nuclear deterrence and cannot be substituted. These decisions were also accompanied by conditions on the principles of consultation and of common rules of engagement, on the management of costs, the contribu-

Insert 2

RUSSIAN INTEGRATED AIR AND MISSILE DEFENSES

Dr Igor Sutyagin, Royal United Services Institute (RUSI)

Russian S-300 VM –MAKS-2013
Wikipedia - Vitaly V. Kuzmin

The need for integration of air and missile defenses originally appeared in the Soviet Union in the early 1960s due to the Soviet military's prevailing views on the operational employment of tactical ballistic missiles. Those Soviet views, mirror-imaged to the NATO, made development of the battlefield tactical ballistic missile defenses (TBMD) the urgent operational need – which caused initiation of the S-300 air defense systems family development in 1969. One particular member of the family – namely the S-300V Ground Troops (land forces) battlefield air defense system (also known as SA-12A/B in the West) - was specifically designed to provide both air, and TBM defenses of the Soviet land forces, thus becoming the first Soviet system specifically designed to provide integrated air and ballistic missile defense (IAMD).

Later on (starting 1975, and especially after the 1990-1991 Gulf War) the task of providing battlefield TBMD, as well as defense against quasi-ballistic targets, was extended to other – i.e. shorter-range – Ground Troops' air defense systems, some of them being specifically designed with that task in mind (Pantsyr-S (aka SA-22) is the best example of that new trend). As the re-armament of the troops with the newer systems is progressing, the Russian land forces are approaching the stage when they will be operating – from brigade level and higher – systems tailored to provide battlefield IAMD.

Meanwhile the idea of integration of air defense assets into the Moscow ABM system attracted the great deal of attention in Moscow since the announcement of the NATO plans to deploy Pershing-II missiles too. That was the first time when supposedly non-strategic ballistic missiles would make the strategic difference for the USSR security in general: it was perceived in the Kremlin that decapitating attack against the Soviet supreme command was one of the Pershing-II's most important combat tasks. While that perception was fundamentally wrong the fear of Pershing-IIs initiated the tectonic change in the Soviet attitudes towards required capabilities of the strategic air defense systems. Ability to engage intermediate-range ballistic missiles has become the standard requirement for future developments of the longer-range air defense systems; that requirement has been inherited by Russia from the Soviet Union.

Given in the constructive similarities between the SA-12B interceptor (9M82 surface-to-air missile) and the PRS-1 (ABM-3A Gazelle) short-range ballistic missile interceptor of the Moscow ABM system, the SA-12 was the natural first candidate for an integrated air and ballistic missile defense (IAMD). Russian Ground Troops' air defense brigades equipped with SA-12 are currently routinely tasked to cooperate with the strategic air defense assets in providing IAMD of key administrative and industrial areas of Russia. Developments of another member of the original S-300 family – the strategic air defense's S-300P (aka SA-10) and its derivatives (SA-20 and S-400, aka SA-21) – have brought it TBMD capability by the mid-1990s too.

The technical achievements were followed by organisational changes in the Russian defense forces – which resulted in establishment of the Russian Air-Space Force's 1st Air Defense and Ballistic Missile Defense Army around Moscow built around the Moscow ABM system and array of SA-20/SA-21 TBMD capable units. That means that the Moscow air defense area currently operates the first fully integrated air and ballistic missile defense system in the world.

tion of the European industry, without forgetting the search for cooperation with Russia, which possesses a deterrence system in the process of modernization and to improve its integrated aerospace defense.

Russia aerospace defense integration and improvement

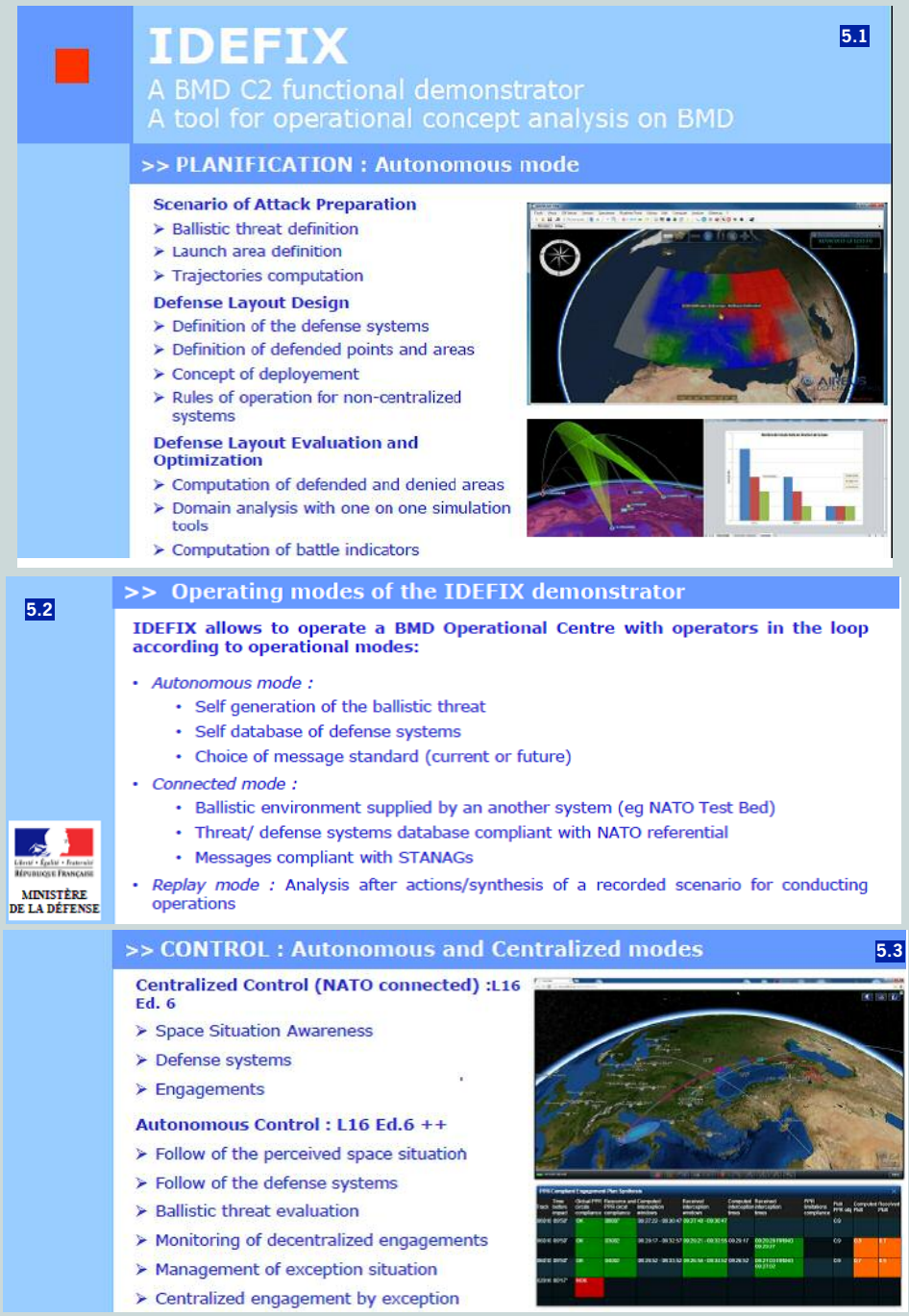
Russia has always considered the air defense and the BMD as a whole to defend its military and strategic assets, together its troops against a wide spectrum of air and missiles threats. In parallel of cooperation with NATO on TMD systems or discussion with NATO and the US on BMD, Russia has been developing its own high and low altitude IAMD systems (see Insert 2, Dr Sutyagin) such as the S300-PMU2, the S400 and the S500 for theater defense or territorial defense. Russia is designing a defense against spatial, ballistic and air threats including MRBMs/IRBM missiles – such a capacity which, unlike the American or NATO projects- is destined to prioritize protection against 'A preemptive strike threat' to strategic Russian including Command Centres, which could weaken their deterrence. Russia has also its mobile theatre defense and its air defense to protect assets and troops against cruise missiles and a modern combat aviation. Russia has moreover totally integrated the command of spatial, air and missile defence into an Aerospace forces Command. All this was described and presented by the Russian authorities during an international Missile Defense conference "Missile Defense: cooperation or confrontation" in Moscow in 2012. IAMD is therefore not new to Russia. A more detailed perspective on the Russian IAMD is given by Dr Sutyain in insert 2. It also seems now that the IAMD is also part of a global access deny doctrine which copes with troops thea-

ter defense and air defense doctrines as it is explained in the Military Doctrine of the Russian Federation[2].

Debates on the threats continue

However, the debates continue on the threat. The crisis in Syria has already demonstrated the reality of a common usage of a conventional and ballistic air threat; in the Syrian territory, more than 500 short range ballistic missiles as well as conventional bombs were fired against soldiers and the population. It was therefore necessary to deploy a system with a 'dual air ballistic missile' defense capacity near to the borders, on the Turkish side. We must also remember the 9/11 scenario, previously unimaginable. The 'terrorist' air threats are taken into account in Europe also and national exercises have been put into place since 9/11 in a Euro-Atlantic context with NATO participation, participation from European countries, and even that of Russia

Figure 5: IDEFIX



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 (Figure 5.1) 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 (Figures 5.2 and 5.3).

2. Quote from the Military Doctrine of the Russian Federation "providing aerospace defence critical objects of the Russian Federation and the readiness to repel attacks air and space attacks".

for certain exercises. A consensus remains to be seen, even at a NATO level, on the hypothesis of an ever present dual threat which targets the territory of the alliance. More recently, the example of Yemen also showed that the Houthis non-governmental forces can get hold of short range ballistic missiles and put them to use, including in salvo, moving on from the age of the old rockets to that of short range ballistic missiles. But to find an expanded consensus also needs to guarantee the respect of territorial integrity and of the airspace of all countries… even before talking about the coordination of the engagement of high altitude ballistic interceptors.

FROM MISSILE DEFENSE TO IAMD

If there is not yet a consensus on all threats, there is not yet one on the choice between BMD and IAMD. The 'Theatre Missile Defense' was vital to the origin of IAMD architecture against dual threats. But it remains an architecture destined to the theatre, while the defense of territories has become a dominating aim driving the US EPAA, for the reason of the evolution of the ballistic threat but the conventional as well and the aims of sovereignty in Europe or the influence of regional politics, for the USA, the Russians, not forgetting the Europeans the first concerned. In effect, the command of the long range BMD reveals its large geographical footprint beyond national borders, the questions of sovereignty and the collective decisions which require a consultation process in order to agree to the rules of engagement and their consequences (debris). Likewise, the tensions with Russia on the Ukraine crisis have evidently reinvigorated the need to guarantee the security of national airspaces, and therefore the importance of air defense. Equally, the territorial BMD, conceived as an expansion of the ALTBMD, would have an intrinsic dual capacity notably linked to NATO's command system and the Air Command and Control System (ACCS). The European and American weapon systems deployed in the air, on land or at sea, are moreover already connected with the NATO BMDOC of Ramstein, with the ACCS which is already in the process of evolution (ACCS TMD), in order to expand its missions to ballistic missile defense. The ACCS ensures as well all the NATO air operations in real time, in line with the NATO integrated air and missile defense system (NATINAMDS) and the national Command & Control Systems based on replications of the ACCS system in NATO Control Centres. This system of NATO command and control is interfaced with the 'Ballistic Missile Defense' command centre of the United States in Europe, the C2BMC, which covers on its side all the American missile defense systems of the US EPAA – the naval & land Aegis systems and alert radar AN-TPY2 in Turkey. All NATO systems share the running of the ballistic 'Situational Awareness' from Ramstein, but the air capacity of the ACCS allows for NATO defense and air operations. The BMD approach therefore, can evolve into an IAMD architecture which, as with any Theatre Missile Defense or NATO territorial BMD defense, would no longer be focused on one single ballistic threat but would join together NATO air defense and NATINAMDS. For certain nations in Europe, the IAMD is seen as a priority equal to that of 'Theatre Missile Defense', especially since more than a few are directly exposed to conventional air threats. Perhaps we will achieve a consensus sooner or later. The NATINAMDS exists, and the American concept of IAMD exists as well for other systems, notably naval with the US navy's cooperative engagement concept (CEC), or for defense applications in countries outside of Europe.

Ballistic Missile Defense for the European Territory

The decision to create a missile defense architecture for the European territory with an integrated command under NATO's responsibility has been taken by the nations in 2010 (Lisbon Summit), with a collective funding of the command system which must include a process of planning and consultation with common rules of engagement and a shared evaluation of interception consequences. It is a new political goal. Different countries are thus conducting exploratory work to compare their approaches to the planning and decision process, one of which is France who have developed a missile defense C2 (Command & Control) demonstrator in order to evaluate the planning and execution phases compatible with the NATO C2 (Figure 5)

Thales has produced many sea based air surveillance SMART-L radars operating in L band for European navies. Since 2012, Thales has developed a new SMART-L MM (Multi Mission) with AESA antenna providing longer range for BMD/ IAMD in naval and land based versions. These radars are currently under integration and functional tests and prepared for first integration on Dutch frigates in 2018

Fig. 6a: SMART-L

Fig. 6b: SMART-L MM/N in integration

Fig. 6c: SMART-L MM/N sea-based version under tests

Fig. 6d: SMART-L MM/F land-based version under tests

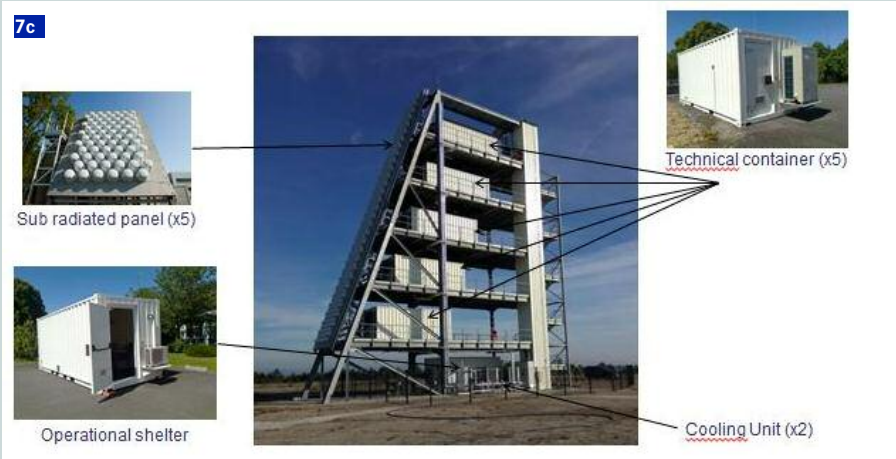
Figure 6: SMART-L family

Figure 7: Very long range alert UHF Radar.

Figure 7a: complete version

Figure 7b: one column reduced scale antenna version

Figure 7c: fully functional operational one column radar



TLP Very Long Range Radar (see Figure 7a) is a key element for early warning function in order to evaluate all types of ballistic threat. This ground-based low frequency sensor is a radar realizing the surveillance and acquisition of the ballistic missile target in its ascending and ballistic phases to produce trajectory parameters. The operation in Low Frequency band brings unsurpassable assets for the long range detection of the high endo and exo atmospheric ballistic missiles. Moreover TLP can provide cueing data to Centimetric band Fire Control Radar by integration in BMD system.

The Very Long Range Radar is an active phased array technology (AESA) and multifunction radar based on fence surveillance interleaved - as soon as a target is detected - with a tracking mode based on specific tracking beams.

French MoD awarded a risk reduction contract to Thales and ONERA in October 2011 for the development and the experimentation of a radar demonstrator) based on the principle of one column of the radar (see Figure 7b) defined in the concept study.

In addition to column, the demonstrator solution (see Figure 7c) integrates real time software in term of signal processing and data processing. In operational radar mode, it includes HMI with Aerospace visualization, supervision statement and built in test dispositive.

The objective of demonstrator is double:

- *Validation of architecture and technology choices*
- *Evaluation of the detection and accuracy performances in order to anticipate operational performances of the Very Long Range Radar*

Nowadays integration on site is closed in order to process phase of experimentation.

Figure 8 : Spatial demonstrator Spirale

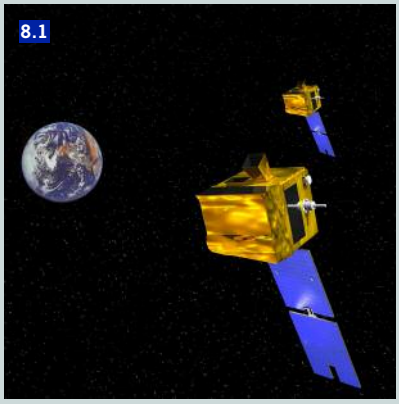


Figure 8.1: Spirale micro satellites
Figure 8.2: IR background images

The experimentation Spirale included 2 microsatellites (see Figure 8.1) equipped with spectral IR imagers (made by ThalesAleniaSpace under the responsability of Arianegroup under the contract of the French ministry of defense (DGA)). The experimentation Spirale has allowed for collecting numerous images in high resolution of the infrared background (figure 8.2) but also to observe IR plumes (missiles and launchers)

Figure 9: Future family of SF/GF AESA Multifunction Radars in S band

Figure 9.1: Future family of S-band Sea Fire (with fixed panels antenna) and Ground Fire (with rotating antenna) AESA radars
Figure 9.2: 4 fixed panels Sea Fire radar
Figure 9.3 : Multi-beam management where dedicated multi-beam patterns are optimized for different tasks such as volume search, horizon fence search and cued target search can be automatically interleaved

Thales prepares the marketing of new generation radars with AESA technology, with a Fully Digital receive chain (FD-AESA), allowing Element Level Digital Beam-forming. Radar products will be available in naval and ground versions (see Figure 9.1), with fixed or rotating panels. Building on the GS1000/M3R demonstrator launched in 2004 and wide experience with air defense radars of the Ground Master 400 class, they combine deep operational experience with the latest technology.
On the new French Navy FTI (Frégate de Taille Intermédiaire) class, the AESA 4 fixed panel Sea Fire radar (Figure 9.2) in S-band is arriving to take the place which was previously fulfilled by the multi-function radar Herakles. Using the same antenna technology as the Sea Fire radar, larger versions to handle BMD missions, and multimission ground versions (Ground Fire) with rotating antenna that can be coupled with the SAMP/T B1NT, are under definition. These radars are modular and allow for the covering of all ranges and powered by the dimensioning of the antenna and the adjustment of the number of Transmit/Receive (TR) modules. The functionalities of the range of radars cover both ABT (Air Breathing Target) and TBM (Tactical Ballistic Missiles) defense roles, and manage the effector component by the inclusion of missile link functionality for the ASTER family of missiles. A high level of performance in surveillance and tracking is attained thanks to the large multi-beam capability (>50 simultaneous beams!) and to the optimization in real time of these multi-beam patterns according to simultaneously performed missions and targets (See Figure 9.3).

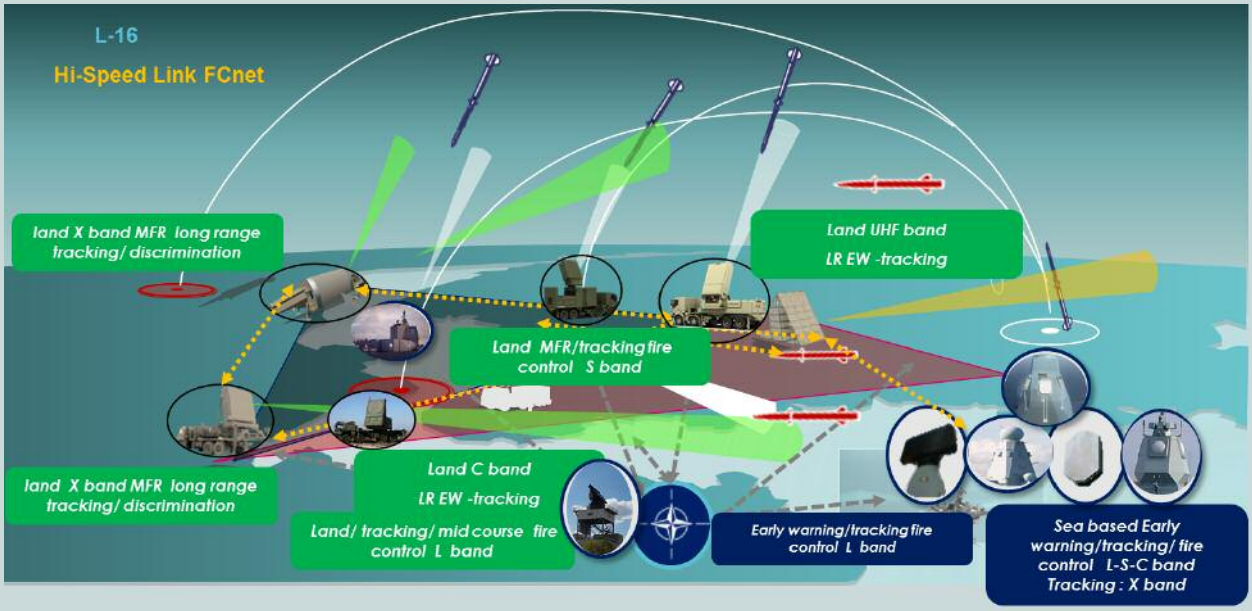
or other countries with tools for evaluating the consequences of interception. The NATO ACCS, whose functions are extended to the theatre missile defense capacity (ACCS TMD) has thus been developed in conjunction with the US and European industries via ThalesRaytheon Systems (joint venture between 2 companies Thales and Raytheon) along with other European and American actors. After the summit in Chicago, NATO asked for more cooperation between nations on a 'smart defense initiative.' Concerning missile defense, certain countries put forward a 'pooling and sharing of US SM3 missiles' whereas others viewed the naval and notably the alert anti-missile capacity as a subject of cooperation.

CAN WE ENVISAGE A BALANCED CONTRIBUTION TO IAMD: WHICH INITIATIVES COMING FROM EUROPE?

In order to arrive at a global consensus on the subject, there needs also to be a more balanced contribution between European countries and the United States, via collective NATO financial contributions. There also needs to be an effort of national defenses budgets to obtain 2% of the national GDP (which is becoming evident in the light of recent terrorist attacks mostly in Europe but also in the USA, and even in Russia, without forgetting Middle East), a demand which was expressed at the NATO Summit in Wales, September 2014 and strongly reminded at the NATO Summit in 2017. This is not easy at a time when defense budgets are already put under immense pressure, but **security and defense are not an obligation perceived with the same priority among some European and American nations?**
Is this collective obligation – of course more in view of mandatory exterior actions rather than for contributions to NAT0 budget - compatible with the effort to develop equipment and defense in certain countries? Can they alleviate their budgetary constraints if they are profiting from a contribution to the collective defensive effort? The assessment of priorities and of needs seems quite different in NATO and in the EU.

The United States have already invested around 2 to 3 billion Dollars in the EPAA , which is remarkable, but some European nations have also invested billions of Euros in air defense systems that are under development, if not operational. For example the Netherlands are developing a system with advanced alert capacity (MM) based on the Smart-L ELR naval radar (Figure 6) at first in naval but also on land version. France, on the other hand, is developing a ground based very long range radar (Figure 7), and has already created an experimental satellite system, Spirale, in order to do tests on spatial missile alerts (Figure 8). France and Italy have also invested billions of Euros in ground-to-air missile system with 100% European technology, based on the Arabel multi-function radar and the Aster 30 missile family (Figures 3 and 4). It has been successfully tested against 'Air-Breathing' targets but also against ballistic missiles. Additional improvements are foreseen on the 'Fire-Control' system and the Aster 30 B1 NT, as well as the development of sea based and ground based sensors applications (Figure 9). Evidently, the investments also continue in Denmark (Smart-L naval system), in Germany with the

Figure 10: Network concept of MFR sensors and firing units assembled in clusters.



The integration of IAMD or antimissile systems goes through the interoperability of Command and Control (C2) Centres and sensors through link16 type network. In addition, new concepts of networking are proposed to assemble Multifunctions Fire Control sensors into clusters through rapid links.
They can improve the system through:
- *The resilience of the systems by balancing resources*
- *The resilience to ECM due to multiple sensors, frequencies and viewing angles*
- *The Improvement of the coverage, battlespace and accuracy*
- *The Subsidiarity and EMCON*

TLVS system derived from MEADS (Figure 4.6), in Italy, in Poland, in Turkey, in the United Kingdom and others, which have future plans to modify or develop their antimissile capabilities in the air and on the ground.

Europe will have to invest more

However, in the economic plan, an investment is essential in Europe as in other places, to accompany developments. Defense officials are therefore being confronted with difficult choices, having strong budgetary constraints, all while maintaining a spending close to 2% of the GDP. For space, they have given priority to investment in military communication and observation satellites, but also in civil satellites and space launchers like Ariane 6. At the same time, they continue with very important investments in the improvement of 'dual lower layer' IAMD systems, like for example the ground-to-air missile platforms. They also favour investment in naval antimissile capacities.
Some ideas exist in Europe and in France to boost the R&D investment on defense with some tools like the "Socle de Defense"[3]. It is based on collecting citizen savings dedicated to defense and security investment. Such an idea might be used to add some more resources to the government budget objectives to reach 2.65% of GDP for defense without increasing the debt. This approach could be also extended to different nations in Europe.

In parallel, concerning the access to the market, the impression persists, well founded or not, that the United States provides principally American's solutions to its partners and that access to the market is a real problem for the European industry, to maintain and develop its competencies. But a weak European industry is a risk for all. Without European added value or return on investment, the investment in defense will diminish regularly. This means that, in the long term, there will be need for more investment from the United States in order to contribute to the security in Europe, with more risks for everybody. Moreover, if the security and defence of any nation in Europe is legitimate, this goal should be part of a common understanding, aiming to stability and not to challenges or arms races with Russia. The defense of the airspace is legitimate for everybody.

3. See the article from MR Wolf https://www.linkedin.com/pulse/un-plan-depargne-pour-financer-les-equipements-de-defense-wolf.

AN EXAMPLE OF TRANSATLANTIC INITIATIVE FOR MORE COOPERATION

Cooperation between the countries could also be improved by IAMD systems not only the NATO chain of command and control, but also by increasing the interoperability between the chain of command and the national systems, sensors and weapons. A concept was proposed to increase the interoperability between the weapon fire control systems by building up networks of sensors and IAMD fire-control systems arranged into clusters (Figure 10). The target effect would be to obtain interoperability in real time between weapons systems and allowing for more synergy between them, also reinforcing their performance and resilience by balancing in real time the energy between the systems, all whilst opening lines of cooperation and additional interoperability beyond the L16 data. The new technologies based on digital Multifunction radars, fast communications and network will enable a real time synchronization of fire control systems, leading to new modes of operations and interoperability. An initiative under the theme of 'multi-sensor cooperation' has also been taken at the end of 2013 by two transatlantic think tanks (3AF was invited by the US Atlantic Council). It was then pursued by 3AF with the contribution of transatlantic industries (17) who have made a white paper entitled 'Study of IAMD sensors networking'. This is now a study named "multisensor networking of fire control systems for IAMD" conducted by a NIAG study Group which started in 2017, gathering 26 companies from 11 nations, with the support of NATO ACT sponsoring. The objective is the design of new standards of interoperability for Multi-Sensor Fire Control Networks.
While the American and European defense industries are sometimes criticized for clashing rather than cooperating, the competition does not prevent the industry from proposing ideas that improve synergy of systems and to reinforce their global effectiveness. Sometimes, the political willingness lacks in order to favor cohesion over competition renowned for guaranteeing the best price, which would be justifiable in abundant budgets, but they are not. The American industry suffered from 'budget sequestration' but has a budget with considerable support from exterior operations, and from FMS contracts, whereas the European Industry, of which the know-how is also undeniable, has been seemingly on a diet for years!

TOWARDS CONSENSUS

A consensus on air and antimissile defense based on a dynamic expansion of the NATO BMD is certain, but only under certain conditions. The dual threat must be a shared priority, and allows for a capitalization of NATO's dual capacities, and of the industries, and notably of theatre defence. The synergy between the industries of the USA and of Europe must be reinforced, creating an added value for the American and European competencies and an equal access to the market, including exports. Finally, the synergy of systems and sensors between them could be improved by the networking of fire control systems. It would put together not only the techniques and the industrial know-how for proposing innovative solutions, but also would create the conditions for a political willingness to favor such synergies, which takes time. IAMD is therefore also a subject of mutual enhancement of defense and security for Europe, NATO, and an improved link with the US with many challenges. Despite a tense environment with Russia, this might be also a balanced approach compatible with a common understanding with Russia's vision of IAMD. Enhancing the security of our airspace and borders is not creating a new challenge of regional BMD against deterrence. This is a subject of technical and political complexity where Europe has a strong role to play. It might be a subject of consensus in Europe, including for industry for which common challenges need to be faced.

ABOUT SAMP/T

CONTINUOUS IMPROVEMENT OF THE SAMP/T TOWARDS SAMP/T NG

Pascal L'Ebrellec (Eurosam)

In 2011, when France activated its first SAMP/T equipped GBAD squadron, it was clearly a game changer in NATO air defense environment. SAMP/T, called MAMBA by French troops was the first European designed, ATBM capable, long range air defense system. SAMP/T has been designed against latest threats, having in mind to improve perceived drawbacks in legacy system.
SAMP/T key features are:

- All round engagement capability, with fast rotating multi-function radar and vertical launch
- True dual capability: the radar coverage allows simultaneaous engagement versus cruise flying nap of the earth and versus ballistic missiles or anti-radiation missiles (90° coverage in elevation)
- High mobility: encamp-decamp time below 25 minutes, limited number of prime movers.
- Interoperability at battery level (L11 and L16). A unique feature allowing netting with TDL without having to go through an upper level command post.
- Low manpower.

Since 2011 Italy also activated its own SAMP/T unit. French and Italian GBAD units demonstrated the uniqueness of SAMP/T in various exercises and demonstrations. For example training in mixed Italian-French GBAD units, providing mobile coverage of Army brigades, netting with AAW ships and AWACS, rapidly deploying from France to Poland in a couple of days, etc. From an IAMD point of

view the key milestones were JPOW 2013 and the 3 live firings against ballistic missiles surrogates. The latest such ATBM firing took place in March 2013, with the SAMP/T being connected to Ramstein through French and NATO networks.
Currently 2 SAMP/T units from Italian Army are deployed in South-East Turkey, as part of the Alliance's Active Fence operation.

Hence SAMP/T is now an established and reckoned with capability for NATO IAMD.
Not resting on their laurels France and Italy, along with UK for the Aster missile, have confirmed their long term commitment to make available a state of the art IAMD capability, keeping up with threat evolution. After a study phase the Nations instructed OCCAR, acting as program and procurement agency, to contract with Eurosam for the evolution of SAMP/T for the foreseeable future.
In December 2015 OCCAR and Eurosam signed the "Sustainment and enhancement contract". The scope encompasses not only SAMP/T but also the Eurosam naval systems, which feature common items with SAMP/T. Indeed the title of the contract says it all about the intent of the nations: to sustain the systems, including SAMP/T, but also to "enhance".

This contract is also dubbed "B1NT", as a key element is the development of a new version of the Aster 30 missile, called B1NT (New Technologies).

Aster B1NT will provide SAMP/T with enhanced ATBM capabilities, expanding the battlespace against more demanding ballistic threats. Along with the NT missile development the fire control system is being updated with an open architecture software and the configuration of the various SAMP/T main equipment will also be modernized. S&E is a multi-steps contract. Late 2016 a first amendment was signed, with some additional features being planned. France and Italy agreed on high level objectives for the roadmap for SAMP/T, with aggressive targets for the enhanced SAMP/T operational capabilities, focusing mainly on increased ATBM performance. It sets the trajectory for what industry now calls "SAMP/T NG". Aside from already decided missile developments, the aim is to expend the combat envelope of the system to allow autonomous use of the full potential of the new missile. Sensors and fire control enhancements are under analysis. Radar studies have been conducted as soon as 2009 in various architectures configurations to provide a long range detection and tracking capacity against TBMs for IAMD along with the integration of new technologies.

SAMP/T - HISTORICAL REMINDER

THE 3RD SUCCESSFUL SAMP/T LIVE FIRING AGAINST TACTICAL BALLISTIC MISSILE IN 2013 IN COORDINATION WITH NATO WAS INTERNATIONALLY RECOGNIZED

Contributors:
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- **Véronique Cham-Meilhac**, Director Business Development Extended Air Defense / Anti-Ballistic Missile Defense (MBDA) ;
- **Luc Dini**, Director of Business Development Missile Defense (Thales), Co chairman of the international Missile Defense conference 3AF.

Presentation of the Technology Pioneer Award during the International AIAA Conference
In the setting of the annual multinational Ballistic Missile defense conference by the AIAA (American Institute of Aeronautics and Astronautics) the American Missile Defense Agency, on proposal of the international program committee, awarded on 6th October 2015 the 'Technology Pioneer Award' (Figure 11) to the French and Italian SAMP/T extended air defense teams. This prize was created in 2008 in order to honour the singular achievement of an individual or a group in advancing missile defense, with a particular emphasis on expanding international cooperation and consensus.

Figure 11: Technology Pioneer Award

Figure 12 : The ARABEL multi-function fire control radar of the SAMP/T weapon system.

Figure 13 : The firing of the Aster 30 B1 missile from the SAMP/T launching module

Figure 14: A photo of the group during the presentation of the award, from right to left: Mr Norm Tew, VP& Program Director, Strategic Missile & Defense Systems, Boeing (USA) sponsor of the AIAA BMD Year 2015 conference - Ms Nancy Morgan, Director for International Affairs, Missile Defense Agency (USA) – Major General (Infantry) Francis Autran, Deputy Strategy Director, Direction Générale de l'Armement (France) - Mme Véronique Cham Meilhac, Director Business Development Extended Air Defense /Anti-Ballistic Missile Defense, MBDA (France) - Vice Admiral Syring, Director, Missile Defense Agency (USA) – Colonel (Armament) Johana Pelletier, Ballistic Missile Defense capacity manager, Direction Générale de l'Armement (France) - Mr Luc Dini, Director Business Development Missile Defense, Thales (France), co-chairman Missile Defense conference (3AF)

This 'Technology Pioneer Award' has rewarded the success of the SAMP/T system carried out 6th March 2013 with the ARABEL fire-control radar and the Aster 30 B1 missile which made direct impact on a target representing a SCUD tactical ballistic missile, interconnecting with the NATO chain of command (Figures 12 à 17).

The Ceremony

Major General Francis Autran, Deputy Strategy Director of the French Direction Générale de l'Armement (DGA), gave a speech to an audience of 300 people from 13 countries, amongst which were American, Spanish and Romanian high authorities. He received the award from Vice-Admiral Syring, director of the Missile Defense Agency (MDA). He was accompanied for the occasion by Colonel (Armament) Johana Pelletier, Ballistic Missile Defense capacity manager within the Direction Générale de l'Armement along with two representatives of the industrial companies MBDA (Ms Véronique Cham-Meilhac) and Thales (Mr Luc Dini), companies who contribute to the SAMP/T system through EUROSAM consortium, and to Integrated Air & Missile Defense in general (See Inserts A, B & C page 22 and 23). All three are members of the AIAA BMD conference international committee and of the 3AF Missile Defense Conference international committee.

Why a live firing against a tactical ballistic missile?

This live firing had the objective to validate the ballistic missile defense operational capacity of the SAMP/T against a SCUD type target and its interoperability with NATO through the use of the Link 16 which enables the SAMP/T to integrate into joint operations.

This event demonstrated the capacity of interception with the ARABEL fire control radar and the Aster 30 Block 1 missile, by direct impact with a SCUD type ballistic target.
The launch was carried out at the DGA Missiles Launch Test Centre in Biscarrosse (see Figure 19), collectively by the fourth artillery regiment of Mantoue (Italy) and the Center of Air Military Expertise (CEAM) in Mont-de-Marsan (see Figure 20). It mobilized the means of various DGA centers and NATO centers as well as an American Aegis destroyer.

Figure 15: The architecture of the missile defense during the live firing, from bottom to top. The Franco-Italian crew operated 2 SAMP/T sections and intercepted a ballistic target, representative of a SCUD type short range missile. The designation of the SAMP/T was done by a local radar situated in Biscarrosse via a L16 datalink. The chain of command consisted of a French C2 center at Bruz which assured the interface with the command center in Ramstein, regrouping the NATO BMDOC with the ACCS system and the US C2BMC command center, linked with an American Aegis destroyer.

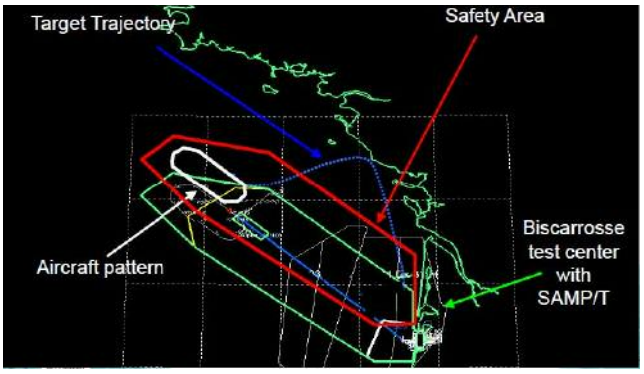

Figure 16: View of the perimeter of the test range during the live trial and the ballistic trajectory in the safety land, naval and aerial zones.

WHAT IS SAMP/T?

The French-Italian SAMP/T weapon system is by conception totally dual and deals simultaneously with conventional air threats and short range ballistic threats.

The main advantages of the SAMP/T are notably the 360°area defense, its mobility and its air transportability for overseas operations. Developed and produced by Thales (responsible for the fire control system) and MBDA (responsible for the Aster missile and launchers) through the consortium EUROSAM, in cooperation between France and Italy, the SAMP/T system is in service in the 2 countries which bring it as national contributions to NATO ballistic missile defense program.

A SAMP/T section (see Figures 17, 18.1 & 18.2) consists of a fire control (an ARABEL multi-function radar and an engagement module) and of 3 to 4 launching modules,

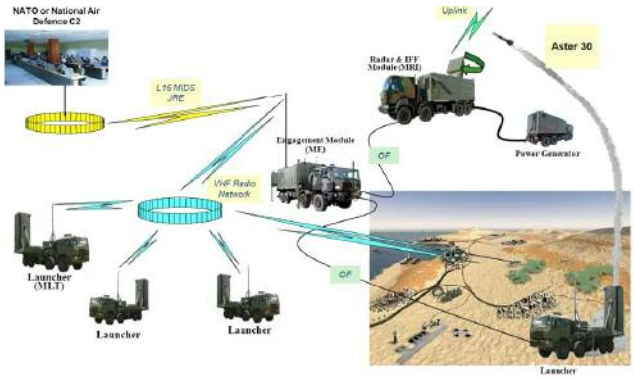

Figure 17: Architecture of the SAMP/T system

Figure 18.1: The ARABEL fire control radar module «The Eye», with the link of the command missile.

Figure 18.2: The Engagement Module of the fire control system, «The Brain».

Figures 18.3 and 18.4: The Launching Modules armed with 8 hyper-velocity Aster missiles, « The sword».

each of them armed with 8 Aster missiles (see Figures 18.3 & 18.4). The SAMP/T is in operation in the French Air Force and the Italian Army.

Conclusion and perspectives

The NATO Summit in July 2016 in Warsaw allowed to take stock of the development of the American contribution to the NATO ballistic missile defense (The European Phased

Adaptive Approach, EPAA, notably with Aegis destroyers, Aegis ashore equipped with SM3 missiles) and of the development of the NATO command and control system, including ACCS, with dual air and missile defense capability. The European contribution to the collective effort is not outdone, despite a difficult situation which could have rendered missile defense inaccessible to the European technologies, in the face of defense budgets and priorities in Europe. However, the national European contribution, notably the French and Italian ones through SAMP/T, find their place in an integrated air and missile defense capability.

The 'Technology Pioneer Award' is therefore an encouraging sign for transatlantic cooperation which underlines that the European effort is real, by way of the important investments already made, and which recognizes the effective and operational contributions of the SAMP/T during NATO exercises. This reward can also prefigure more synergies between American and European systems, in Europe and in crisis areas – which are also regions of partnership, cooperation and exportation. The interception of cruise or ballistic missiles by direct impact is an accomplished reality by each partner, both American and European, with their special features. It's a matter of defending aerospace areas against threats which are not illusions but a reality if you observe the weapons recently deployed in the Middle East (cruise missiles, long range rockets or short range ballistic missiles), some of which are already available to non-governmental groups. The SAMP/T equipped with the Aster 30 Block 1 missile responds to this protection need and will continue to evolve.

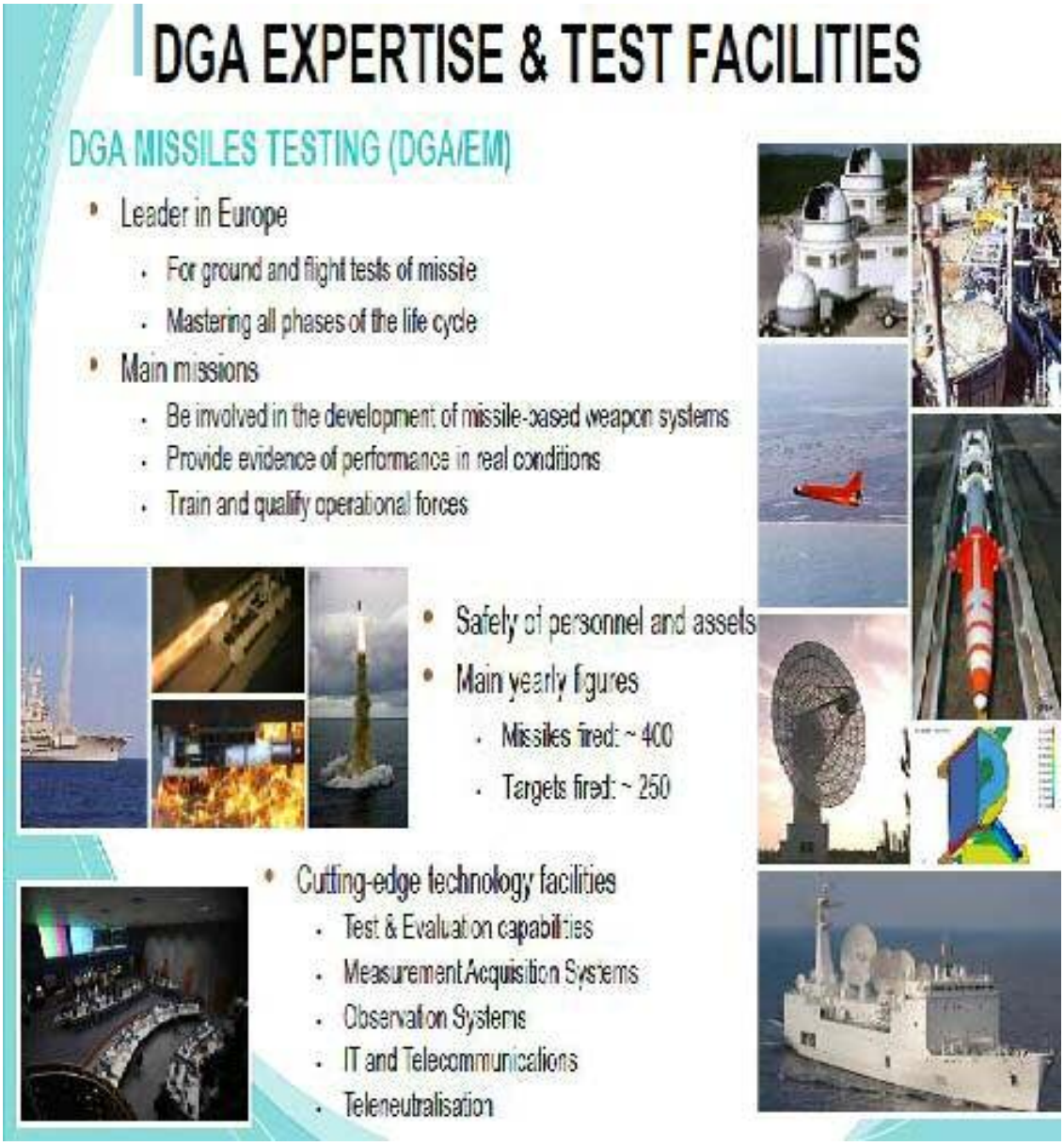

Figure 19: DGA Missiles testing

Figure 20: personnel at CEAM Air Defense System Mark Team 13.330 were involved in the ATOC ATBM live firing for the operational implementation of the French SAMP/T. Their recognized expertise allows them to interface their coordination systems and ground air defense with different systems of the centre of air defense expertise (CEAM), for the experimentation phases, but equally with air force systems and our allies for operational missions and exercises.

Insert A

EUROSAM was created in June 1989 by 3 large groups of the European Aerospace industry (Aerospatiale, Alenia & Thomson-CSF) known today as MBDA missiles and Thales respectively.

EUROSAM is the primary contractor and system design authority on development, production and marketing-sales of long and medium range ground and naval systems, also known as the 'Future Surface-to-Air Family' (FSAF).

These systems were developed under French & Italian government contracts, which succeeded at the end of the eighties with similar conclusions for the specification of their operational air defense systems. This would require ground & naval systems capable of dealing with diverse threats such as high speed tactical missiles (supersonic sea skimmer missiles, warplane missiles, ARM, cruise missiles, tactical ballistic missiles and other types) as well as highly maneuverable aircraft in the configurations of overwhelming attacks. The key capacity of these systems is the ability to engage multiple targets simultaneously regardless of their combination in 360°.

The naval systems (Surface-to-air Anti-missile Systems SAAM and SAAM AD/PAAMS) for protecting naval units use Aster 15 and Aster 30 missiles guided by Arabel or EMPAR radars.

The medium range surface-to-air system (SAMP/T) uses Aster 30 missiles guided by the Arabel radar and, for French and Italian teams, acts as a replacement for the Hawk air defense system. The French air force has also recovered its long range engagement capacity which had been lost with the end of the Nike system.

Insert B

MBDA, European leader in missile systems, boasting a vast experience in the development and production of programs carried out in multinational cooperation, has for many years launched studies and developments of weapons systems for Extended Air Defense, namely for the systems operating the ASTER missiles.

Beyond its contribution to NATO Ballistic Missile Defense to establish a database of future threats, MBDA has participated to the BMD studies of the Alliance, and in France has demonstrated its expertise on the characterization of the TBM maneuverable threat, by winning numerous studies.

MBDA has also developed a solid know-how in technical simulations of the systems operating the ASTER missile and the assessment of their associated performance.

For the whole range of ASTER systems, MBDA is the prime contractor of the missile, the launchers and in some cases of the naval firing installations.

The ASTER missile, by design, integrates a wide range of defense architectures and platforms both in naval and ground environments to deliver an Integrated Air & Missile Defense capability.

Developed in FR/IT cooperation in its ground application, and in FR/IT/UK cooperation in its naval application, the ASTER missile is the weapon of choice for more than 70 Extended Air Defense systems worldwide: the Italian Army and the French Air Force operate the ASTER missile within the SAMP/T, the French, Italian and British Navies within the PAAMS systems, and Export countries operate the ASTER missile in ground and naval applications.

A dual missile, the Block 1 ground version has endured a 100% successful test program and demonstrated hit-to-kill capability through several successful live firings against short range ballistic type targets as well as exceptional capabilities against the conventional air targets: aircraft, tactical and cruise missiles…

FR and IT committed to further cooperate in the ASTER family by signing the contract in December 2016 including the development of the dual Block 1NT upgrade . This upgrade significantly improves the intercept capabilities and the kill probabilities of the interceptor, against more complex threats, and faster threats of longer range.

The SAMP/T with the ASTER 30 Block 1 also constitutes the voluntary national French and Italian contributions to the BMD mission of the Alliance.

Insert C

Thales is a key actor with a large portfolio of IAMD activities from the NATO Air C4I using the ACCS system through ThalesRaytheonSystem, a joint venture with Raytheon, as well as the C2 GBADOC mobile coordination systems for air defense.

It's completed by space, naval (SMART-L) and ground Early Warning systems, with UHF long range radars made with ONERA.

Subsequently, Thales contributes to the IAMD weapon systems through the management of the SAMP/T fire control system (B1 and B1NT improved versions), namely the X band ARABEL radar, which exists in a naval version (PA CDG, Sawari2) and the PAAMS fire control of the Horizon Frigates, via EUROSAM. Finally, Thales provides the multifunction, S band, MFR Herakles for FREMM frigates and develops new electronics for the future S band active antennas for the Sea Fire 4 fixed panels MFR radar for the FTI French Fregate. Using the same antenna technology as the Sea Fire radar, larger versions to handle BMD missions, and ground versions that can be coupled with the SAMP/T B1NT, are under definition. In its role as a supplier, Thales develops the electronics for the seeker of the Aster missiles, which the future NT Ka seeker is planned for with the Aster B1NT.

In parallel, Thales plays a key role in the integration and testing of national & NATO IAMD systems. Among these integration and validation tests, for the last 10 years Thales has taken part in the program of system engineering and integration (SE&I) of NATO ballistic missile defence architecture, but also in national platform tests including tests on firing ranges and trials. Thales was present in 2006 at the trials of the SMART-L in Hawaii, in 2010, 2011 and 2013 for the Franco-Italian ATBM & SAMP/T live firing in Biscarosse. Thales was also present in the JPOW exercises with NATO in 2013 and in 2015, and the naval trials of the ASD 15 in Scotland (MFR Herakles Radar of the FREMM and the SMART-L radar of the Dutch frigate which detected and pursued ballistic targets). Thales will participate to new tests in 2017.