Air Defense Integration and Interoperability Challenges within the NATO Alliance

A Monograph

by

COL Daniel L. Swanson
US Army

School of Advanced Military Studies
US Army Command and General Staff College
Fort Leavenworth, KS

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The ability to defend NATO allies from a regional adversary air attack in the low-medium threat category has become increasingly strained since the fall of the Soviet Union in 1992. NATO has a limited capability and capacity to defend itself against the emerging air threats such as ballistic missiles, cruise missiles, unmanned aerial systems, and traditional fixed and rotary wing platforms.

The challenges associated with NATO's challenges to integrate the differing air defense weapon systems among the alliance are attributed to four primary obstacles. They are identified in the areas of technical integration due to diverse weapons systems, limited command and control data architecture, foreign disclosure processes and agreements and finally the national level of commitment to resource material interoperability.

The guidance and direction of integration and interoperability between NATO allied countries is a sound concept in theory. The execution of integration and interoperability of differing air defense weapons systems is achievable during a bilateral training exercise through work arounds and ad hoc task organizations. These unique solutions are short lived and not a long-term or strategic solution to a holistic integrated air and missile defense network capable of defeating a regional air threat in an alliance as robust as NATO.

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____//signed 21 April 2021/BMS//_____, Monograph Director
Barry M. Stentiford, PhD

__//signed/29 April 21/BAP//_____, Director, School of Advanced Military Studies
Brian A. Payne, COL

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_____, Assistant Dean of Academics for Degree Programs
Dale F. Spurlin, PhD and Research, CGSC

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Abstract

Air Defense Integration and Interoperability Challenges within the NATO Alliance, by COL Daniel L. Swanson, 47 pages.

The ability to defend NATO allies from a regional adversary air attack in the low-medium threat category has become increasingly strained since the fall of the Soviet Union in 1992. NATO has a limited capability and capacity to defend itself against the emerging air threats such as ballistic missiles, cruise missiles, unmanned aerial systems, and traditional fixed and rotary wing platforms. US and NATO strategic guidance both direct interoperability and discuss the importance of interoperability and integration among the NATO alliance. The benefits of integration and interoperability allow the alliance to share the cost burden of expensive high-tech air defense weapon systems and enhance the alliance's ability to defeat, deny, and disrupt enemy air threats. Though the guidance of integration and interoperability between alliance members is clear at the strategic level, implementation and execution at the tactical and operational levels are extremely problematic.

The challenges associated with NATO's challenges to integrate the differing air defense weapon systems among the alliance are attributed to four primary obstacles. They are identified in the areas of technical integration due to diverse weapons systems, limited command and control data architecture, foreign disclosure processes and agreements and finally the national level of commitment to resource material interoperability.

The guidance and direction of integration and interoperability between NATO allied countries is a sound concept in theory. The execution of integration and interoperability of differing air defense weapons systems is achievable during a bilateral training exercise through work arounds and ad hoc task organizations. These unique solutions are short lived and not a long-term or strategic solution to a holistic integrated air and missile defense network capable of defeating a regional air threat in an alliance as robust as NATO.

Until the alliance can come to a consensus on a holistic integrated data network; allies' sensors and shooters will be stove piped and limited in their capacity to defeat an air threat from a regional adversary. The idea of a holistic integrated data network can only work if the United States re-examines its foreign disclosure policies on the integration of allies into a plug and play type network.

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Abbreviations

A2AD	Anti-Access/Area Denial
ABT	Air Breathing Threat
AMD	Air and Missile Defense
BM	Ballistic Missile
BMD	Ballistic Missile Defense
BMDOC	Ballistic Missile Defense Operations Cell
C2	Command and Control
CM	Cruise Missile
CMD	Cruise Missile Defense
C-RAM	Counter Rocket Artillery and Mortars
C-UAS	Counter Unmanned Aerial Systems
EPAA	European Phased Adaptive Approach
FW	Fixed Wing
GBAD	Ground Based Air Defense
IAMD	Integrated Air and Missile Defense
MDO	Multi-Domain Operations
NATINADS	NATO's Integrated Air Defense System
NASAMS	National Advanced Air Defense System
NATO	North Atlantic Treaty Organization
RW	Rotary Wing
SHORAD	Short Range Air Defense
TBM	Theatre Ballistic Missile
THAAD	Terminal High Altitude Area Defense
UAS	Unmanned Aerial System

Introduction

None of this is going to matter if you're dead. And that's why you need air defense.

- General Mark Milley, former US Army Chief of Staff

The North Atlantic Treaty Organization (NATO) was formed in 1949 with twelve nations allying together to provide a collective security against the Soviet Union. During the Cold War NATO established a formidable air defense network that consisted of multinational integrated air defense weapons systems that provided twenty-four hour, seven-days-a-week readiness, and command and control (C2) sectors. The systems were networked together through NATO's Integrated Air Defense System (NATINADS). The NATO integrated air defense forces had a unified Area Air Defense Plan (AADP), training and evaluation systems, doctrine, and OPLANs that were developed and executed specifically towards the Soviet Union and Warsaw-Pact countries' air threat. The collapse of the Soviet Union in the early 1990s led to the reduction of NATO's air defense capability and capacity to include the NATO integrated air defense system.[1]

Since 1949 the NATO alliance has grown from twelve original members to thirty in 2021. The growth of NATO brought an increase in its territorial boundaries to include former Warsaw-Pact countries. These former Warsaw-Pact countries brought with them legacy military equipment to include outdated Soviet era air defense artillery weapon systems that have limited ability to integrate with the Western developed air defense systems and are significantly behind in the technology and capability advances. The programmatic area is where the hardware and software technology gap are fully in display. The US air defense capabilities are ahead of even its most technologically capable allies, and many new and NATO members are using obsolete 1960s

[1] G.W Pronk, "The Importance of Integrated Air and Missile Defense Training," *The Journal of the Joint Air Power Competence Centre* 30 (Spring/Summer 2020): 78–84.

and 1970s technologies.[2] With the resurgence of Russia as a regional threat and the proliferation of theater ballistic missiles (TBM), cruise missiles (CM), and un-manned aerial systems (UAS), NATO and the United States have found themselves in a capability and capacity shortfall when deterring these threats. Currently within NATO, only seventeen countries maintain an air defense artillery weapon system. Six of the seventeen allied countries are currently using, or have purchased, the US developed Patriot missile weapon system with Link-16 capability. Of the remaining twenty-three allied countries, only eleven possess air defense artillery weapon systems, which were purchased from various defense contractors world-wide to include Turkey's most recent purchase of the Russian made S-400 air defense weapon system.

The United States' three primary strategy documents, *National Security Strategy* (NSS), *National Defense Strategy* (NDS), and the *National Military Strategy* (NMS), all provide descriptive guidance that the United States must pursue a future force that is lethal, agile, and move towards an integrated force with its allies that allows for cost burden sharing. These documents state that the key to the United States leveraging their allies is through the development, and continued expansion, of interoperable command and control, and air defense artillery weapon systems. The United States furthered its interoperability approach through support of the European Phased Adaptive Approach (EPAA) to deter and defeat Iranian ballistic missiles by employing the Aegis Ashore weapon systems to Poland and Romania.[3] The EPAA is an example of what can be accomplished when NATO agrees on the threat and the systems to defeat that threat. With the proliferation of cruise missiles, unmanned aerial systems, and an air

[2] Robert Ackerman, "In NATO, Technology Challenges Yield to Political Interoperability Hurdles," *Signal* (February 2006), accessed December 14, 2020, https://www.afcea.org/content/nato-technology-challenges-yield-political-interoperability-hurdles.

[3] Jen Judson, "Capacity, Interoperability Still Plague Europe Missile Defense," *Defense News* (July 31, 2017), accessed December 17, 2020, https://www.defensenews.com/smr/european-balance-of-power/2017/07/31/capacity-interoperability-still-plague-european-missile-defense/.

threat from the low-and medium category, the NATO alliance has not made defeating these regional threats a priority due to cost and no agreed upon threat.

The enemy is proliferating area access and denial (A2AD) systems at a faster rate than the United States can close the capability and capacity gaps to defeat this threat. One strategic end is utilizing allies to join in the cost burden sharing in the defense of critical assets. It is believed from the political and strategic level that the United States must build a force that has full interoperable capabilities with their allies. With interoperability, comes an integrated coalition that is capable of jointly defeating a regional threat from the sky. The importance of interoperability lies within the actual ability to execute on the battlefield. The inability to be an integrated force with our allies and coalition partners will continue to increase the requirements for the US air defense artillery weapons system that are already deployed to maximum capacity.

Interoperability and integration among NATO allies and coalition partners is a strategic message that delivers the perception that the United States and its allies are a cohesive, integrated, fighting force ready to defeat any enemy that threatens the alliance or interests abroad. The perception of allied victory against the air threat is achieved through a consolidated network of all sensors that is shared to all end users, through a joint integrated command and control network that input is received and utilized by all NATO partners. This network seamlessly integrates all NATO ally's air defense artillery weapon systems and sensors to a centralized command and control node that correlates air tracks and controls fires for all ground-based air defense weapon systems during a conflict. In reality the strategic messaging of interoperability is just messaging. Interoperability at the operational and tactical levels is currently being executed in a bilateral capacity with work arounds, but not to the level policy and strategic messaging depict.[4] The interoperability between US air defense artillery weapon systems and sensors and their NATO allies are constrained by foreign disclosure bureaucracy, technical integration obstacles,

[4] Ackerman, "In NATO, Technology Challenges Yield to Political Interoperability Hurdles."

software/hardware incompatibility, lack of long-term commitment, and the lack of European national resourcing and consensus. Though the challenges of integration and interoperability between NATO and United States are significant, the following sections will attempt to answer the question: "Is achieving integration and interoperability between the United States and other NATO countries at the tactical, operational, and strategic levels achievable to develop a NATO integrated air and missile defense shield against a regional threat?"

The research for this monograph was conducted in four parts. The first research area explored the definitions of interoperability at the policy, strategic, operational, and tactical levels of interoperability and integration. Understanding the perception/definition of interoperability explains how interoperability by definition is executed. The second area of research was to develop a doctrinal understanding of the US guidance and definition of what integrated air and missile defense is and the weapon systems that are employed to execute that mission. The third area of research was directed at understanding the history of NATO's air defense efforts compared to the current status of NATO air defense forces and how they are employed. To understand the processes of integration and interoperability within the NATO alliance the research examined the vast number of air defense artillery systems and sensors currently within NATO. The research identified the current NATO air defense weapons systems and their ability to integrate with NATO and US air defense artillery weapon systems and sensors over a recognized link architecture. The fourth research area was understanding the US foreign disclosure policies and its effect on data sharing, integration and the sales of US air defense artillery weapon systems to NATO partners through foreign military sales (FMS). Within this same scope of research, the exploration of European and Canadian willingness to purchase US developed weapons systems and command and control networks. Finally, the research explored the data link architectures to develop an understanding of what resources were available to integrate US and NATO air defense weapons systems.

Literature Review

This section offers insight into the factual data and opinions that are currently available on interoperability and the importance to increase partnership capacity within the NATO alliance. The 2019 RAND Corporation research paper "Targeted Interoperability" gives an accurate perspective of written literature and content in regards to interoperability:

> In modern warfare, hardly a conversation about military capabilities occurs where interoperability with another organization—multinational or not—does not come up. Significant literature exists on all types of interoperability, with the common refrain being that *more* and *better* interoperability is needed. And, with few exceptions in recent decades, the United States tends to engage with multinational partners and allies in military operations, thus bringing multinational interoperability to the fore.[5]

The "more *interoperability* the better" is the common theme throughout most documents written on interoperability. National strategic guidance, Joint Chiefs of Staff Guidance, Army Regulation, NATO vision statements, and countless articles are very clear that the United States and its allies need interoperability. Therein lies the unanswered questions in the published literature: why is the United States not interoperable with its NATO partners as it desires and directed?

The three highest national level documents used in directing national strategic guidance call for interoperability between the United States and its allied partners. The *2018 National Defense Strategy* states the military must, "Deepen interoperability. Each ally and partner are unique. Combined forces able to act together coherently and effectively to achieve military objectives requires interoperability. Interoperability is a priority for operational concepts, modular force elements, communications, information sharing, and equipment."[6]

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[5] Christopher G. Pernin et al, *Targeted Interoperability: A New Imperative for Multinational Operations*, Research report RR-2075-A (Santa Monica, CA: RAND Corporation, 2019), xiii.

[6] Jim Mattis, *Summary of the 2018 National Defense Strategy*, 11, accessed December 16, 2020, https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

In the *2017 National Security Strategy*, former President Donald Trump stated, "[t]he United States will seek areas of cooperation with competitors from a position of strength, foremost by ensuring our military power is second to none and fully integrated with our allies and all of our instruments of power."[7] Finally the *2018 National Military Strategy* acknowledges, "[t]he unique contributions of allies and partners, a strategic source of strength for the Joint Force. Building a strong, agile, and resilient force requires better interoperability and enhancing the combat lethality and survivability of our allies and partners."[8] The desire for the interoperability between the United States and its NATO allies is mentioned in all of the most current national strategic guidance. The term *interoperability* pushes an agenda of cohesiveness, strong alliance, and increased capacity among allies, but these documents fail to define interoperability and how do we know if we have achieved it.

"*Interoperability* is the ability to act together coherently, effectively, and efficiently to achieve tactical, operational, and strategic objectives," according to *Army Regulation (AR) 34-1 Interoperability*.[9] The theme of AR 34-1 definition of interoperability is generally the same throughout many of the documents published. These documents define interoperability as working together with allied countries to achieve a tactical, operational, and strategic goal to build partner capacity. The *2011 Journal of Defense Resource Management*, states, "[a] key aspect of the new policy is the new definition of NATO interoperability: Interoperability is the ability to act together, coherently, effectively and efficiently to achieve Allied tactical, operational and strategic objective."[10] The definition of interoperability in its broadest sense has

[7] Donald Trump, *National Security Strategy of the United States* (Washington, DC, December 2017), 26.

[8] Department of Defense, Joint Staff, *Description of the National Military Strategy 2018* (Washington, DC: Department of Defense, n.d.), 3.

[9] Department of the Army Headquarters, *Army Regulation 34-1, Interoperability* (Washington, DC: Government Printing Office, April 2020), 1.

[10] Florian Ciocan, "Perspectives on Interoperability Integration within NATO Defense Planning Process," *Journal of Defense Resources Management* 29, no. 2 (2011): 56.

not changed according to the 2019 RAND article "Targeted Interoperability" The inherent issue from the published literature is that interoperability is broadly interpreted in its definition which rarely provides the end user a solid reference of how interoperability is achieved or measured.

When the term *interoperability* is dissected, it is apparent that *interoperability* is a much more complicated process that intertwines conditions, technical challenges, users, political agreements, hardware, training, and relationships to achieve the desired effect of interoperability. Many of the current publications provide many directions or layers on how interoperability can be achieved. Robert K. Ackerman, author of "In NATO Technology Challenges Yield to Political Interoperability Hurdles", wrote, "[t]he challenge of achieving coalition interoperability in three different areas: the technical area, which focuses on architectures and standards; the programmatic area, which involves affecting national programs to achieve interoperability; and the political and cultural levels."[11] There is not one defined approach on what the different layers of interoperability consist. The current publications suggest that interoperability is executed at the strategic, operational, and tactical levels and they each have a role in ensuring success of the other echelons. Within those echelons there are lines of effort that aid in defining interoperability. For instance, "Andreas Tolk's model describes nine layers of coalition interoperability (LCI): (1) Physical Interoperability, (2) Protocol Interoperability, (3) Data/Object Model Interoperability, (4) Information Interoperability, (5) Knowledge/Awareness, (6) Aligned Procedures, (7) Aligned Operations, (8) Harmonized/Strategy Doctrines, and (9) Political Objectives."[12] Tolk defines interoperability as, "the ability to make use of functionality offered by other components to increase the functionality offered by the own system."[13] There is not one agreed holistic approach to achieve interoperability as defined in the national strategic documents. The challenges of

[11] Ackerman, "In NATO, Technology Challenges Yield to Political Interoperability Hurdles."

[12] Andreas Tolk, "Beyond Technical Interoperability" (June 2003): 18-19, accessed January 6, 2021, https://apps.dtic.mil/sti/pdfs/ADA466775.pdf.

[13] Ibid., 2.

interoperability presented in the publications continue past, definitions, dissecting the layers, and understanding the lines of effort associated with interoperability.

There is very specific strategic guidance that the US military must strive towards interoperability with their coalition partners.[14] However, the ability to achieve interoperability to the level of the previous defined standards is layered with many challenges besides definitions and executable theories. The technological gap, political cultures, and national programs are all areas that are identified in why interoperability is not being executed to its full capacity. Michele Zanini, author, *The Army and the Multinational Force Compatibility*, stated,

> Yet the discrepancy in modernization priorities and budgets between the United States and even its closest allies will increase the likelihood of incompatibilities in any effort. The technology gap that characterized past operations will continue to grow. Overall, it is clear that Force XXI developments will generally exacerbate current coalition problems-technically, operationally, and politically-and will prove more challenging than in the past.[15]

Ackerman concurs with that technology gap assessment but also offers and additional challenge facing NATO interoperability, "[t]he greatest challenge facing NATO interoperability is the desire of individual nations to safeguard information and technology from their allies, according to the general manager of the agency tasked with enabling coalition interoperability."[16] Interoperability among the NATO allies has been identified as important and has directed the military to achieve interoperability with the United States and NATO partners. The identified road blocks with interoperability are limiting the progress of interoperability between the United States and its NATO partners in the realm of integrated air and missile defense (IAMD).

Interoperability is an integral part to the United States and NATO being able to conduct integrated air and missile defense operations as an alliance if called upon. *The Air and Missile*

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[14] Jim Mattis, *Summary of the 2018 National Defense Strategy*, 9, accessed December 16, 2020, https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

[15] Michele Zanini and Jennifer M. Taw, *The Army and Multinational Force Compatibility* (Santa Monica, CA: RAND, 2000), 25.

[16] Ackerman, "In NATO, Technology Challenges Yield to Political Interoperability Hurdles."

Defense Vision 2028 directs the United States' Army Europe's highest air defense artillery echelon, the 10th Army Air and Missile Defense Command (AAMDC), to focus on integrated air and missile defense and partner engagements across Europe primarily on interoperability and building operational depth.[17] General Phillip M. Breedlove (ret), former EUCOM Commander, states, "[o]ne of the most urgent requirements is integrated air defense, an effort that will require investments at the national and NATO levels. This will necessitate close coordination to ensure that sensors, shooters, and command and control systems are available and aligned to provide layered air defense." *The 2019 Missile Defense Review* reinforces General Breedlove's previous statement and *The Air and Missile Defense Vision 2028* on the importance of AMD interoperability with NATO and coalition partners:

> The United States will pursue enhanced missile defense cooperation with allies and partners, place a renewed emphasis on interoperability, and seek to integrate capabilities as appropriate. Successfully operating in today's complex missile threat environment demands that we detect launches as soon as possible, track them, and intercept them as early in flight as feasible. This requires interoperability among various missile defense capabilities to include command and control networks, sensors, and Integrated Air and Missile Defense (IAMD) systems. Moving towards networks of interoperable IAMD systems can take advantage of cost-sharing and help distribute the burden of common defense to better address adversary A2/AD strategies.[18]

Publications support the idea of increasing interoperability with coalition and NATO partners to increase capacity of AMD and partner burden sharing. Increasing capacity through burden sharing has been reiterated in doctrine and publications since the 1990s.

There are publications that depict the success NATO has had with the integration of like air defense artillery weapon systems. The interoperability for NATO countries that have purchased and employ Patriot extends to joint training exercises, as well as the ability to come to an ally's defense. "In 2013, Dutch, German and US Patriot batteries deployed to Turkey to defend

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[17] Air and Missile Defense Integration Division, USASMDC, *Army Air and Missile Defense 2028*, March 2019, 15.

[18] Office of The Secretary of Defense, *Missile Defense Review*, 2019, 16, accessed January 19, 2021, https://www.defense.gov/Portals/1/Interactive/2018/11-2019-Missile-Defense-Review/The%202019%20MDR_Executive%20Summary.pdf.

that country's citizens and coalition forces from a possible Syrian-based ballistic missile attack. Those forces then rotated out in 2015 and were replaced by Spanish forces."[19] This example of interoperability is what the desired end state as described for NATO and its ballistic missile defense (BMD) force.

Followed by the NATO doctrinal approach to ballistic missile defense versus defeating and air threat and finally identify the challenges of interoperability between the United States and NATO through various obstacles. Finally deciding the feasibility of implementing a holistic interoperability approach to increase the interoperability and integration of NATO air defense artillery weapon systems by aligning technical integration, foreign disclosure policies, and national willingness to modernize weapons systems and command and control architectures. The following sections will discuss the US doctrinal approach to integrated air and missile defense.

United States Integrated Air and Missile Defense

In 2017 the army published its modernization strategy naming air and missile defense as one of its top six priorities.[20] The *National Security Strategy* (NSS) and the *National Military Strategy* (NMS) both emphasis the need for increase integrated ballistic missile defense and cruise missile defense. The air domain is large and the plethora of weapons that threaten the United States and its allies from the sky are vast in their varying platforms. US Army, Field Manual 3-01, *US Army Air and Missile Defense Operations*, states:

> The emerging air and missile threats encompass a wide range of missiles, rockets, projectiles, and air platforms. The number of countries developing weapons of mass destruction is unconstrained, and delivery systems with increasing range and accuracy are

[19] Vivienne Machi, "NATO Missile Defense Systems Strive for Interoperability," *National Defense* (July 31, 2017), accessed December 21, 2020, https://www.nationaldefensemagazine.org/articles/2017/7/31/nato-missile-defense-systems-strive-for-interoperability.

[20] David L. Mann, Roger F. Mathews, and Francis G. Mahon, "'None of This Is Going to Matter If You're Dead': Modernizing Integrated Air and Missile Defense Must Remain Army's Top Priority," *Real Clear Defense* (June 16, 2020), accessed December, 17, 2020, https://www.realcleardefense.com/articles/2020/06/16/none_of_this_is_going_to_matter_if_youre_dead__modernizing_integrated_air_and_missile_defense_must_remain_armys_top_priority_115381.html.

being sought and developed. Compounding these threats is the potential for or initiation of electronic and cyber-attacks.[21]

The call for increased air and missile defense capacity and modernization is being voiced from the national strategic level and the senior leadership of the US Army. The following section will provide focus on what is integrated air and missile defense and the US air defense artillery weapon systems in its inventory that comprise integrated air and missile defense.

Doctrinally integrated air and missile defense is the action of defending an asset from an aerial attack. Within the definition of integrated air and missile defense there are many layers and it is necessary to understand the components within integrated air and missile defense and the threats in which it protects against. Joint Publication 3-01, *Countering Air and missile Threats*, defines the following terms:

> *Integrated Air and Missile Defense* is the integration of capabilities and overlapping operations to defend the homeland and US national interests, protect the joint force, and enable freedom of action by negating an enemy's ability to create adverse effects from their air and missile capabilities.[22]
>
> *Air and Missile Defense* is the direct [active and passive] defensive actions taken to destroy, nullify, or reduce the effectiveness of hostile air and ballistic missile threats against friendly forces and assets.
>
> *Air Defense* is the defensive measure designed to destroy attacking enemy aircraft or aerodynamic missiles, or to nullify or reduce the effectiveness of such attack.
>
> *Air Defense Artillery* are the weapons and equipment for actively combating air targets from the ground.

The US Army air defense forces have five mission sets with the capabilities to deny, disrupt, and defeat enemy air and ballistic missile threats. These five missions are: ballistic missile defense (BMD), cruise missile defense (CMD), manned and unmanned fixed wing (FW) and rotary wing (RW) aircraft, counter-UAS (C-UAS), and counter rocket, artillery and mortar

[21] Headquarters, and Department of the Army, *FM 3-01 US Army Air and Missile Defense Operations* (Washington, DC: Government Printing Office, 2020), 3–3.

[22] US Department of Defense, Joint Staff, *Joint Publication (JP) 3-01 Countering Air and Missile Threats* (Washington, DC: Government Printing Office, 2017), GL-7.

(C-RAM).[23] The threat type for these missions are vast in their capabilities to attack United States and allied assets. The varying degree of threats require differing air defense artillery weapons systems to be employed on the battlefield to defeat these threats. Integration and interoperability are the advantages the United States has in developing a unified common operation picture among its air defense weapon systems. The *Army Air and Missile Defense Vision 2028* discusses air and missile defense operations in Multi Domain Operations (MDO):

> These areas span the MDO framework: the BMD capabilities protect assets in the Strategic through Tactical Support Areas and assist other forces in getting to and conducting the deep fight. CMD and FW/RW aircraft defense forces protect assets in the Operational and Tactical Support Areas and the Close Area. The C-UAS and C-RAM capabilities support the fight in the Close Area. Many Army AMD sensors and shooters have capabilities against more than one threat set. Satellites supplement the surveillance capabilities of ground-based sensors, enable long-range communications, and provide situational awareness and warnings.[24]

The breadth of research will focus solely on the ground-based air defense (GBAD) systems employed by the United States and NATO allies. Air defense artillery weapon systems are employed on the battlefield to deny, disrupt, and defeat an enemy threat from the air domain to a protected asset.

The air and missile defense echelons have five separate missions but are interdependent of each other through integration and interoperability. Ballistic missile defense and the defense of assets against an air breathing threat are separated by threat type. Within the US air and missile defense construct it is necessary to integrate those missions in being able to deny, disrupt, and defeat enemy air and missile threats. The grouping of the five air domain challenges as previously discussed are further grouped into two distinctive categories, ballistic missiles and air threats.

> Air and missile threats encompass ballistic missiles, air threats, and rockets, artillery, and mortars. A ballistic missile is any missile that does not rely on aerodynamic surfaces to produce lift and consequently follows a ballistic trajectory when thrust is terminated. Air

[23] Air and Missile Defense Integration Division, USASMDC, *Army Air and Missile Defense 2028.*

[24] Ibid., 8-9.

> threats include manned fixed- and rotary- wing aircraft, UASs, and aerodynamic missiles. Rockets, artillery, and mortars comprise the indirect fire threat.[25]

The defense against ballistic missiles has been the primary focus for the US Army air defense forces since the Gulf War in 1991. The proliferation of ballistic missiles over the past twenty-five years has significantly enhanced the modernization of the US Army ballistic missile defense weapon systems at the expense of the air threat weapon systems also known as short range air defense capabilities. The US ballistic missile defense systems (BMDS) capabilities are arrayed in to separate tiers that maximize the capability of the air defense artillery weapon systems capabilities. The *US Army Field Manual 3-01* defines these layers as Upper Tier and Lower Tier:

> *Upper tier* is a layer of airspace that encompasses very high altitudes within the atmosphere to outside the atmosphere in which air and missile defense engagements are conducted. Upper tier systems are designed to defeat ballistic missiles, from intercontinental to short-range variants, during the mid-course and early terminal phases of their flight.[26]

> *Lower tier* is a layer of low-to-high airspace within the atmosphere in which air and missile defense engagements are conducted. Lower tier systems are designed to defeat close-, short-, and medium-range ballistic missiles during the terminal phase of their flight.

The *US Army Field Manual 3-01* explains, components of the BMDS architecture is the integration of ground-based midcourse defense (GMD), command and control battle management and communications (C2BMC), joint tactical ground station (JTAGS), AN/TPY-2 radar in forward based mode, Theater High Altitude Area Defense (THAAD), and Patriot missile weapon systems.[27] NATO has adopted the US strategy of BMDS through the European Phased Adaptive Approach and the employment of Aegis Ashore weapon systems in Poland and Romania. NATOs

[25] Headquarters, and Department of the Army, *FM 3-01 US Army Air and Missile Defense Operations*, 3–3.

[26] Ibid., A-1.

[27] Ibid., A-1.

approach to integrated air and missile defense ends with missile defense. NATO does not have an a fully integrated or interoperable approach to the defeat of the regional enemy air threat.[28]

The limited US Army inventory against the air threat has become a priority for the modernization of air defense artillery weapon systems that are employed to defeat low and medium range altitude air breathing threats. In the early 2000s the US Army depleted its capability and capacity to defend the maneuver force from an air threat:

> While Army AMD forces provide capabilities against BM threats, they do not possess adequate defenses against air threats to the maneuvering forces in the close fight and the fixed and semi fixed assets that support maneuver forces. The re-emergence of great power competition has left our maneuver forces and key assets vulnerable to enemy air surveillance, targeting, and attack from aerial platforms.[29]

The Stinger missile-based weapons platform, the Linebacker, was removed from the inventory and the Avenger weapon system was reduced to two active duty battalions within the air defense artillery arsenal. Capability gaps emerged during conflicts in the middle east for defending itself against rockets and mortars thus the development and employment of the Counter Rocket and Mortar (C-RAM) weapon systems. Patriot missile battalions continue to have the capability to defend against the low-medium altitude air threat but capacity issues and rotations to the middle east keep the Patriot force engaged in BMD operations. The army lacks the capability and capacity to defend the maneuver force against the significant varying air threat platforms such as cruise missiles, RW/FW, and UAS. The *Army Air and Missile Defense 2028*, states, "[a]s part of the response to these requirements, the Army is expanding the number of AMD short-range systems, enhancing SHORAD capabilities and growing AMD formations."[30]

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[28] Luc Dini, "Air and Missile Defense in Europe: Building a Consensus," *Friends of Europe* (April 1, 2015), accessed December 19, 2020, https://www.friendsofeurope.org/insights/air-and-missile-defence-in-europe-building-a-consensus/.

[29] Air and Missile Defense Integration Division, USASMDC, *Army Air and Missile Defense 2028*, 10.

[30] Ibid., 10.

The modernization of the air defense artillery force is designed to close the capability gaps of the low-medium air threat between the United States' and their adversaries. In response, the US Army has developed the Maneuver Short Range Air Defense (M-SHORAD) weapon system.[31] The M-SHORAD weapons system is the first air defense weapon system on a Stryker platform and will be fielded in 2021 to the first M-SHORAD battalion in Europe. The integration of all air defense artillery weapon systems continues to be an integral part of executing the air defense mission to support multi domain operations. The key to the integration of the air defense forces is the development and fielding of the common integrated and networked C2 (IBCS) in 2022:

> When fully fielded, IBCS will be a game changing capability, allowing AMD forces to be tailored and scaled appropriately to meet the given threat. The right number and mix of capabilities can be task organized into a formation with an inherent, integrated C2 system. The IBCS open architecture will enable rapid integration of legacy and developmental sensors and shooters, providing capabilities to defeat emerging threats in Multi-Domain Operations.[32]

The US Army air and missile defense force have the capabilities to deny, disrupt, and defeat the ballistic missile threat and is modernizing its force to close the air threat gaps. Though the current ballistic missile capabilities are present and the air threat capabilities are emerging the issue still remains with the US air defense artillery capacity. With limited resources and emerging regional threats, the United States will be forced to lean on its allies for assistance in defending assets from the air domain threat in future operations.

United States Air Defense Artillery Weapon Systems in Europe

The United States has four types of ground-based air defense artillery sensors or weapons systems that are forward stationed in Europe to support and defend NATO and the European Commanders critical assets against ballistic missile and air threats. The capacity of the European

[31] Ibid., 10.

[32] Air and Missile Defense Integration Division, USASMDC, *Army Air and Missile Defense 2028,* 12.

theater air defense forces against a regional air threat is limited to one Avenger battalion and one Patriot missile battalion stationed in Germany. The United States also supports NATO BMD with the employment of one forward-based mode AN/TPY-2 Radar in Turkey and two Aegis Ashore sites in Poland and Romania. As stated in the *National Security Strategy* and the *National Military Strategy*, air and missile defense capability and capacity has become a priority for the United States to defend against a ballistic missile and air threat in Europe.

The US Army has one of only two short range air defense battalions in the army inventory stationed in Germany. The 5th Battalion, 4th Air Defense Artillery Regiment located in Ansbach, Germany is an Avenger weapon system air defense artillery battalion. The avenger weapon system is a Stinger missile, ground-based air defense weapon system that is designed to deny, disrupt, and defeat against a low altitude threat:

> The Avenger weapon system is a mobile lightweight, day or night, limited adverse weather fire unit used to counter enemy reconnaissance, surveillance, and target acquisition efforts and low-level fixed- and rotary-wing threats. Avenger contains missile pods carrying Stinger infra-red homing, fire-and-forget missiles and a M3P .50 caliber machinegun mounted on a high mobility multipurpose wheeled vehicle (also known as HMMWV).
>
> Avenger formations include the Avenger weapon system, Sentinel radars, and FAAD C2.[33]

The Avenger weapon system is the only one of its kind currently in Europe and is being replaced by the Maneuver-Short Range Air Defense (M-SHORAD) weapon system in FY21. The AN/MPQ-64 Sentinel radar that is employed within 5-4 ADA BN will remain as part of its Modified Table of Organization and Equipment (MTOE). The Sentinel radar used for SHORAD operations is a highly versatile radar that is shared by two former Warsaw-Pact countries and is the primary sensor for the National Advanced Air Defense System (NASAMS). NASAMS is a Norwegian short to medium ground-based air defense weapon system developed by Raytheon

[33] Headquarters, and Department of the Army, *FM 3-01 US Army Air and Missile Defense Operations*, B-6.

and Kongsberg.[34] The United States owns and employs one NASAMS battalion in the National Capital Region (NCR) but is not forward stationed in support of the European Commander. Though the Sentinel radar is used throughout the European theater the integration between the United States and its NATO allies is limited due to software upgrades on the US Sentinel radars and foreign disclosure challenges, thus making interoperability extremely difficult in a multi-national operation or exercise.

The high to medium altitude air defense weapons system forward stationed in Europe is known as the Patriot missile weapon system. The Patriot weapon system was developed by Raytheon with upgraded launching stations developed by Lockheed Martin. The Patriot missile weapon system is the foundation of US air and missile defense and is currently owned and employed by six NATO allies:

> Patriot is a multi-mission system that provides AMD of combat land forces and other critical assets. Patriot forces are capable of defending against ballistic missiles, cruise missiles, UASs, tactical air-to-surface missiles, large-caliber rockets, and fixed- and rotary-wing aircraft.
>
> The Patriot radar set provides precise three-dimensional search and detection, target track and discrimination, and a Patriot missile uplink to support defense against close-range, short-range and selected medium-range ballistic missiles and the full gamut of air threats.
>
> Patriot launching stations, or launchers, house, transport, store, and fire Patriot missiles capable of long-range, low-to-high altitude, all-weather defeat of close-, short-, and medium- range ballistic missiles.[35]

Just as the Sentinel radar, the US Patriot system is limited in its ability to fully integrate with its NATO allies due to system upgrades and foreign disclosure challenges.

The following two air defense weapons systems are used solely for the NATO BMD against an Iranian ballistic missile attack. These weapons systems are not used against an air

[34] Kongsberg Defense and Aerospace, "NASAMS Air Defense System," last modified August 2019, accessed January 13, 2021, https://www.kongsberg.com/globalassets/kda/products/defence-and-security/integrated-air-and-missile-defence/nasams-air-defence-system/19_08_2019-brosjyre-nasams-air-defence-system.pdf.

[35] Headquarters, and Department of the Army, *FM 3-01 US Army Air and Missile Defense Operations*, B1–B2.

threat and are integrated through the NATO Ballistic Missile Defense Operations Cell (BMDOC), located at NATO Allied Command, Ramstein Germany.[36] The forward-based mode AN/TPY-2 Radar is currently forward stationed in Turkey to support in the defense of the NATO alliance from an Iranian ballistic missile attack. The FBM AN/TPY-2 radar is the sensor that is employed with the Theater High Altitude Air Defense (THAAD) weapon system. When the AN/TPY-2 is forward-based mode it only has surveillance and detect capability:

> AN/TPY-2 radars are high precision, long range, three-dimensional X-band, phased-array radars having two modes of deployment: forward-based and terminal. In the forward-based mode, the AN/TPY-2 radar primarily supports BMDS by detecting ballistic missiles early in their flight and providing precise tracking information. The radar provides boost phase identification, discrimination, early warning/surveillance, and tracking of ballistic missiles for the theater and global BMDS kill chains.[37]

The AN/TPY-2 radar's early warning capabilities is integrated with the NATO BMDOC at Ramstein Air Base and provides detection and queuing for the Aegis Ashore sites in Poland and Romania. The AN/TPY-2 radar supports the European Phased Adaptive Approach[38] that was developed to deny, deter, disrupt, an Iranian ballistic missile attack on NATO allies in Europe.

The final US ground-based air defense weapon system in Europe is the Aegis Ashore weapon systems in Poland and Romania. The Aegis Ashore weapon system is the ground-based air defense weapons system that has detect and intercept capabilities against an Iranian ballistic missile targeting a NATO ally:

> Aegis Ashore is the land-based variant of the Navy's Aegis Weapons System and the centerpiece of Phases II and III of the European Phased Adaptive Approach (EPAA). The system incorporates land-based versions of the various components used on Aegis ships, including the deckhouse, AN/SPY-1 radar, the Mark 41 Vertical Launching System

[36] NCI Agency, "NATO's Ballistic Missile Defense Program Gets a Makeover," last modified November 25, 2019, accessed January 5, 2021, https://www.ncia.nato.int/about-us/newsroom/natos-ballistic-missile-defence-programme-gets-a-makeover.html.

[37] Headquarters, and Department of the Army, *FM 3-01 US Army Air and Missile Defense Operations,* A-4.

[38] Ian Williams, "Aegis Ashore," *Missile Threat, CSIS Missile Defense Project* (April 14, 2016), accessed January 9, 2021, https://missilethreat.csis.org/defsys/aegis-ashore/.

(VLS), and Standard Missile-3 (SM-3) interceptors. It is intended to serve as a midcourse defense against medium and intermediate-range missiles.[39]

The United States has the capability to defend NATO and the EUCOM Commander's critical assets from many threats from the air domain with stand-alone systems. The integration and interoperability between NATO air defense forces in the ballistic missile fight is the priority for NATO as seen through the European Phased Adaptive Approach. The forward stationed US air defense weapon systems prepared to defend against the Iranian ballistic missile attacks have proven to be integrated and interoperable in the defense of NATO. However, the capability and capacity against the regional air threat is inadequate. NATO partner's low-medium air defense artillery systems are extremely varied and limited in capability that make interoperability extremely challenging to execute integrated air defense operations with multinational partners.

NATO Integrated Air and Missile Defense: How did we get here?

After the fall of the Soviet Union, integration and interoperability of the NATO air defense weapon systems downsized and took a drastic shift away from a regional air threat and focused solely on ballistic missile defense. The purpose of this section is to provide the historical context on how the established NATO integrated air defense architecture during the Cold War era was depleted during the 1990s with a shift in threat focus from a Soviet threat to an Iranian ballistic missile threat. This resulted in a NATO air defense force focused on BMD instead of interoperability of its middle and lower tier air defense capabilities.

In 1978 the Army Procurement Research Office (APRO), published, *NATO Standardization and Interoperability Handbook of Lessons Learned*. This document encourages the United States and NATO to use industry to build weapon systems that were interoperable to be used against the Warsaw-Pact countries in the event of escalation between NATO and the Soviet Union. The challenges associated with interoperability in 1978 remain relevant in 2021:

[39] Ibid.

> Standardization and interoperability have been North Atlantic Treaty Organization (NATO) objectives since the alliance was formed in 1949. Nevertheless, a variety of obstacles - political, cultural, economic, technical and military - has prevented achievement of acceptable levels of NATO standardization and interoperability. Improvements in the conventional strength of Warsaw Pact forces and the increasing costs of modern weapon systems have motivated the United States (US) and other NATO countries to make a fresh start toward accomplishment of these objectives.[40]

Forty years later, many of those Warsaw-Pact countries with their varied weapon systems are now part of NATO. To understand todays challenges of integrated air and missile defense within the NATO alliance, this section will discuss the fall of the Soviet Union, the reduction of C2 nodes and integrated air and missile defense capacity, increased ballistic missile defense funding and capacity, and the European Phase Adaptive Approach.

Collapse of the Soviet Union

During the Cold War, NATO forces were arrayed to deter a Warsaw-Pact attack in to the NATO allied countries. NATO air defense forces were on a twenty-four hour, seven days a week alert status. These air defense forces consisted of US developed Hawk and Nike Hercules air defense weapon systems purchased and manned by five NATO allies. The integration and interoperability of the NATO air defense shield during the cold war was brought together through NATO's Integrated Air Defense System (NATINADS). The Joint Air Power Competence Centre article, "The Importance of Integrated Air and Missile Defense Training" reinforces the complexities involved with defending NATO countries from a Soviet surprise attack from the air domain:

> NATO's defense of Western Europe during the Cold War was structured into areas of responsibility, where the ground forces were responsible for their respective Corps areas and the tactical air defense forces protected the area above them. To be able to counter a surprise Soviet (air) attack, air defense forces were at a state of high readiness, 24/7. The NATO integrated air defense consisted of multiple layers of different Surface to Air Missile (SAM) systems, combined with air defense fighter aircraft, each in their own

[40] William B. Williams, Virginia W. Perry, and Harold F. Candy, *NATO Standardization and Interoperability - Handbook of Lessons Learned:* (Fort Belvoir, VA: Defense Technical Information Center, December 1, 1978), 1, accessed December 28, 2020, http://www.dtic.mil/docs/citations/ADA065634.

> designated areas. Coordination took place through very precise procedures, guarded and executed by dedicated Air C2 nodes.[41]

This array of forces remained constant throughout the 1980s into the 1990s with the addition of the US developed Patriot missile air defense weapon system that became fully operational in 1985. The necessity of a NATO integrated air defense network of systems to defend against a Soviet attack began its decline with the fall of the Soviet Union in 1992.

The air defense forces defending NATO assets during the Cold War were phased out of the operational landscape. Without a Soviet air threat, the desire for a large air defense force in NATO was not a priority.

> After the Cold War, the C2 nodes of NATO's Integrated Air Defense System (NATINADS) were rapidly dismantled. National C2 nodes shrank to the minimum needed for peacetime operations and NATO kept on reducing its C2 entities until 2011. At this point, an absolute minimum of C2 entities were kept operational to manage the peacetime mission.
>
> Along with these large cuts in C2 nodes, NATO practically doubled its European territory towards the east with the incorporation of new member states joining NATO. In these former Warsaw-Pact countries, first priority for investment and improvements in the area of defense was not the expensive high-tech air defense systems that were commonplace in the west. The resources that were available originated from former Soviet stocks and were in no way technically compatible with the 'western' equipment used by the 'older' NATO members.[42]

NATO began disassembling its integrated air defense program soon after the collapse of the Soviet Union. NATO believed they had air superiority and would not require an integrated air defense force. NATO actions in Kosovo coupled with a perceived air superiority served as a reinforcement for the decision to reduce costly integrated air defense capacity. At the same time NATO was reducing its integrated air defense forces, the United States had just completed combat operations in Operation Desert Storm. The Patriot missile weapon system that was used to assist NATO in the defense against a Soviet air strike would find itself in a different mission set in which the Patriot missile system was not originally designed for, the defeat of theater

[41] G.W Pronk, "The Importance of Integrated Air and Missile Defense Training," 79.

[42] Ibid., 80.

ballistic missiles. Thus, setting a two-decade course that changed the NATO air defense role from an integrated air breathing threat to a primary ballistic missile defense and air policing mission.

European Phased Adaptive Approach

The proliferation of ballistic missiles is a threat to NATO allies in Europe and North America. The change in threat assessment from protecting against a Soviet attack has now been directed towards Iranian ballistic missiles.

> At the Lisbon Summit in November 2010, NATO leaders decided to develop a territorial ballistic missile defense (BMD) capability. In May 2012 at the Chicago Summit, NATO leaders declared the Interim NATO BMD Capability as a first operationally meaningful step. It offered the maximum coverage within available means to defend NATO's populations, territory and forces across southern Europe against a limited ballistic missile attack.[43]

The European Phased Adaptive Approach is NATOs and the United States' solution to the growing ballistic missile threat towards NATO security from the air domain. The shift of air defense protection of the 1990s to the defense against Iranian ballistic missiles has redirected money and resources from the NATO lower and middle tier protection against ABTs, UAVs, and CMs. This shift in focus has slowed interoperability growth and the ability to integrate US and NATO air defense weapon systems against a regional threat as directed by US and NATO strategic documents.

The current NATO structure provides an integrated air picture focused on the ballistic missile threat from Iran in support of the EPAA. Currently this integrated air picture does not support the interoperability of middle and lower tier air defense weapon systems thus leaving the NATO allies without the ability to integrate and establish a common operating air picture:

> The cornerstone is the NATO Command and Control in Ramstein, Germany with the Air Command and Control Systems (ACCS), part of the NATO Integrated Air Defense System (NATINADS). It is interfaced with the U.S. Command Control linked to the phased EPAA systems – Aegis, AN-TPY2 in Turkey. They share ballistic situational awareness, but not air capacity. It is not an IAMD architecture as long as the EPAA

[43] NATO Public Diplomacy Division, "2016 NATO BMD Fact Sheet" (NATO, July 2016), 1, accessed February 6, 2021, https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_2016_07/20160630_1607-factsheet-bmd-en.pdf.

> architecture and the NATO BMD territorial defense remain so focused on the ballistic threat.[44]

Currently in NATO there are seventeen different types of air defense low-medium air defense artillery systems that were developed in seven different countries with limited to no integration or interoperability capabilities for multinational operations. There are thirty countries in the NATO alliance with seventeen of the countries possessing low-medium air defense artillery weapon systems. Only six of the seventeen NATO countries employ the US developed Patriot missile system.[45] The remaining air defense artillery weapons systems were developed in five different western NATO countries and six former Warsaw-Pact countries comprised of Soviet era air defense weapon systems.

> New NATO member states, mainly from former Warsaw Pact nations utilising pre-90s Soviet air defense capabilities, face significant challenges when interoperating with established NATO nations who employ mainly more modern Western air defence systems. These capabilities are integrated together via Link 16 datalink architecture. Each NATO nation possesses different radio networks for voice and data.[46]

NATO has increased in terrestrial size with the addition of former Warsaw-Pact countries while at the same time decreased its air and missile defense arsenal against a low-medium air threat. The renewed focus on ballistic missile defense in NATO has left a capacity and capability gap against a regional air threat. Therein lies the problem as NATO moves forward in trying to close those gaps. Air defense artillery weapon systems are expensive and the United States only shares one weapon system with six additional NATO allies. Though six NATO countries employs the Patriot missile weapon system, the hardware and software are different due to upgrades, and foreign disclosure remains to be a constant challenge for multinational operations and training events

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[44] Luc Dini, "Air and Missile Defense in Europe: Building a Consensus."

[45] Raytheon, *Missile Defense Update: Keeping Europe Safe*, May 2018, 7, accessed December 15, 2020, https://www.raytheon.com/sites/default/files/2018-05/European%20Missile%20Defence%20Update_May2018_0.pdf.

[46] NATO Industrial Advisory Group, *NIAG SG-220 Study on GBAD Operations in the 21st Century*, October 2019, J-2.

Integration Obstacles

In previous sections the concept of integrated air and missile defense from a US doctrine perspective has been defined, the identification of the US air defense artillery weapons systems has been explained, the vastly different air defense weapons systems between NATO allies has been discussed and finally the history of NATO integrated air defense from the 1960s to its current ballistic missile defense status has been explained. The question that remains is; "what are the challenges that are prohibiting NATO and US air defense artillery weapon systems from achieving interoperability?" The current obstacles that are preventing NATO to achieve interoperability among its air defense weapons systems are identified in the areas of technical integration due to diverse weapons systems, limited command and control data architecture, foreign disclosure processes and agreements and the national level of commitment to resource material interoperability.

Technical Integration

Interoperability through technical integration between NATO allies is a known and obvious challenge for interoperability. The 2019 RAND Study, "Targeted Interoperability A New Imperative for Multinational Operations" states,

> The main challenges to building interoperability are quite well known. They have existed since nations began working together, and are highlighted time and time again in lessons-learned documents generated after operations or through training and exercises.[47]

The RAND study identifies five challenges that prevent NATO allies from achieving interoperability as defined in the literature review. For the purpose of this monograph the focused RAND technical integration challenge will be on Communications and Information's Systems (CIS) interoperability. The RAND Study defines the following challenge:

> *Communications and Information Systems (CIS) interoperability*: the ability for CIS between nations able to connect and work together.

[47] Pernin et al, *Targeted Interoperability*, xiv.

> CIS interoperability is the ability of the force to communicate and pass information using technical means to create a shared understanding within the organization, while also providing the infrastructure to quickly disseminate the intent.[48]

The ability to link one air defense weapon system to another to develop a recognized air picture that provides real time, fire control quality data, that can be passed over an integrated network should be the desired end state for integrated air and missile defense operations in NATO. Command and control is a priority for engaging air threats in an active air domain to prevent fratricide, friendly track correlation and identification of friend of foe (IFF) through a recognized air picture (RAP).

The growth of the NATO alliance increased the strain on former Warsaw-Pact countries to integrate their Soviet made weapon systems with western developed air defense weapons systems. Currently there are seventeen countries that possess air defense artillery weapons systems, of those seventeen countries seven of those employ former Soviet-bloc era air defense weapon systems. These Soviet-made systems do not possess the communications and information systems capability to integrate with the newer western developed air defense platforms. The NATO Industrial Advisory Group (NIAG) final report on "GBAD Operations in the 21st Century" states,

> New NATO member states, mainly from former Warsaw Pact nations utilising pre-90s Soviet air defense capabilities, face significant challenges when interoperating with established NATO nations who employ mainly more modern Western air defence systems. These capabilities are integrated together via Link 16 datalink architecture. Each NATO nation possesses different radio networks for voice and data.[49]

The challenges created for NATO are to take modern air defense weapon systems and integrate the legacy Soviet developed air defense systems. Many of these former Warsaw-Pact nations do not have the capability to maintain the base NATO Link-1 connection. As western NATO countries modernized their air defense inventory the former Warsaw-Pact countries were

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[48] Ibid., xiv, 44.

[49] NATO Industrial Advisory Group, *NIAG SG-220 Study on GBAD Operations in the 21st Century*, J-2.

recipients of legacy or hand-me-down systems from NATO nations. This resulted in more legacy systems on the battle field that lacked the capability to integrate during multinational operations. During recent exercises between the United States and former Warsaw-Pact countries, the United States had to plan for operators to act as liaisons to conduct swivel chair operations to translate the Link-16 fire control data to a legacy data link. The inability to integrate with Soviet and western NATO allies air defense artillery weapon systems is not just a legacy equipment issue. New air defense weapon systems on the battlefield continue to encounter challenges when trying to integrate with fellow NATO ally's communication and information systems.

As NATO and United States continue to develop and modernize their air defense artillery inventory the requirement for integration is still pressing due to limited capacity against a regional threat. Lieutenant General Ben Hodges, former United States Army Europe Commander, stated in the *Defense News* article, "Capacity, interoperability still plagues European missile defense":

> The United States and its allies in Europe don't have enough missile defense capability and still have a long way to go to tie all of the varying systems together into one networked web.
>
> Just the capacity, we don't have enough, that is all there is to it. When you think about all the different critical airfields, ports, cities, facilities that need to be protected, we have a lot of work to do in that regard.
>
> [M]ission command must also improve such as the ability to plug into NATO and other U.S. defense capabilities.
>
> [I]t's also important to figure out how to get all the various air and missile defense systems in Europe to talk to each other and work together no matter the mix.[50]

As European countries and the United States work towards increasing their air defense capacity there will always be a desire for more air defense protection. The challenge of communications and information system integration continue to plague NATO and the United States. European and US industry are accused of working against each other as opposed to finding operable solutions of integrating sensors.[51] The integral foundation in NATO and the United States to

[50] Jen Judson, "Capacity, Interoperability Still Plague Europe Missile Defense."

[51] Luc Dini, "Air and Missile Defense in Europe: Building a Consensus."

increase its air defense artillery capacity can be increased through integration of their varied weapon systems.

Network Obstacles

The United States uses a data link architecture known as TADIL-J/Link-16 as its primary means to share and integrate its airborne and ground based air defense platforms to develop a recognized air picture:

> Link 16 can provide a range of combat information in near-real time to U.S. and NATO allies' combat aircraft and C2 centers. The displayed information includes an integrated air picture with both friendly and hostile aircraft locations, general situational awareness data, and amplifying data on air and ground targets, including air defense threats.[52]

The Link-16 data network is recognized and used by NATO but it is not a holistic network used by all NATO countries. The Link-16 network is currently used by limited NATO countries for data sharing is not a free flow of information or data. Many NATO nations are hesitant to purchase the hardware to employ Link-16 in their weapons systems. RAND Study, "Interoperability: A Continuing Challenge" states, "although many NATO nations would like a Link 16 capability, they are reluctant to buy JTIDS terminals off the shelf from U.S. industry; European nations want to preserve their own defense development and production industrial base."[53]

The number of NATO end users are limited, the Link-16 network is becoming less capable of handling the flow and speed of the data transfer that is required for target interception. COL William Darne, former Training & Doctrine Command Capabilities Manager (TCM) for Army Air and Missile Defense Command, stated at the Association of the US Army (AUSA) conference, "There's no doubt we need that network capability because of the rate of speed at

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[52] Myron Hura et al., *Interoperability: A Continuing Challenge in Coalition Air Operations* (RAND Corporation, 2000), 109, accessed December 4, 2020, https://www.rand.org/pubs/monograph_reports/MR1235.html.

[53] Ibid., 116.

which we process information ... Currently the Army relies on Link-16, the NATO standard datalink, he said, but "with Link-16, there are latency issues that we have that cause problems."[54] The NATO Industrial Advisory Group (NIAG) study, "GBAD Operations in the 21st Century" provided the same concern as COL Darne referencing Link-16 latency and resolution challenges with the integration of communications and information systems:

> Today's Link-16 network data latency and data resolution/precision does not support the large volumes of data and new types of data required to be passed across the GBAD network to support all needed GBAD system development. With airborne/elevated sensors, UASs with ISR packages, organic air defense radars, passive sensors will all be feeding into the GBAD network. This will require more advanced fusion functions to track, identify and classify the widening range of aerial threats. NATO nations will need to invest in enhanced data rate supplementary higher capacity networks, especially at the sensor cluster level, to maximize available sensor inputs whilst avoiding costly redesign of the entire Link-16 network.[55]

The technical integration of NATO and US air defense artillery weapons systems is severely hampered by legacy Soviet and western developed weapons systems. NATO does not have a standard technical platform that is the agreed upon mode of integration among NATO partners.

The strategic and political shift to NATO BMD through the European Phased Adaptive Approach was a catalyst for the low-medium air defense artillery weapons platforms to be either ignored or developed in a vacuum due to funds being allocated towards ballistic missile defense vice air threats. NATO allies now find themselves with limited capability and capacity to defend against a regional threat and more concerning is the in ability to integrate different weapon systems limits NATOs ability to increase capacity. The Joint Air Power Competence Centre article "The Importance of Integrated Air and Missile Defense Training" states that NATO allies have lost the art of executing air defense and the capability to integrate their systems due to lack of command and control nodes:

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[54] Sydney J. Freedberg Jr., "Achilles Heel of Army Air and Missile Defense: The Network," *Breaking Defense* (February 15, 2017), accessed January 16, 2021, https://breakingdefense.com/2017/02/achilles-heel-of-army-air-missile-defense-the-network/.

[55] NATO Industrial Advisory Group, *NIAG SG-220 Study on GBAD Operations in the 21st Century*, 71.

> Looking at NATO's current capability and the average preparedness level of the Alliance, it appears that we are far removed from that early nineties level-of-readiness. With a focus on Ballistic Missile Defense, we have been neglecting the art of traditional air defense for Ground Based Air Defense (GBAD) units as well as the Air Command and Control (C2) nodes.
>
> The full system of IAMD not only lacks a C2 capability and air defense resources, but the interoperability challenges NATO faces between these scarcely available resources are quite challenging.[56]

NATO and the United States have the ballistic missile defense architecture established through the Ballistic Missile Defense Operations Center (BMDOC) located at Ramstein Airbase in Germany, but the alliance's formal ability to integrate the low-medium air defense artillery platforms at the strategic, operational, and tactical is almost non-existent without having to develop an untested or ad-hoc work around.

Short Term Solution: Work Arounds

Strategic messaging, senior leadership briefings, published doctrine, exercise after action reports on NATO interoperability portray a positive picture on the integration and interoperability between NATO and US air defense artillery forces. Though the outpouring of positive messaging is correct, it is often misleading to the casual reader or bystander. The statements made on interoperability are true but do not reveal the challenges involved. The United States and a NATO country are able to integrate their air defense weapon systems for a training exercise, this is normally a bilateral exercise and extensive behind the scenes planning and coordination are done months before that exercise. For these exercises there is no plug and play C2 architecture established for NATO and US air defense artillery forces. The RAND Study "Targeted Interoperability" findings show that interoperability can be achieved on a limited scale but work arounds is not indicative to establishing a foundation of interoperability for all of NATO:

> Indeed, policies and culture may not easily allow it, but all of those constraints can be dealt with. On the other hand, what is often poorly understood are the significant efforts that are involved, and specific and often ad hoc work- arounds and solutions that are implemented to make multinational units interoperable. Studies show that even within a

[56] G.W Pronk, "The Importance of Integrated Air and Missile Defense Training." 79.

> single-nation context, achieving interoperability among individual services is no easy feat.[57]

Often the US air defense artillery units will provide the equipment and personnel for the duration to enable the technical integration between the differing air defense weapons systems. This false sense of integration and interoperability comes in the form of work arounds. These work arounds allow for a successful training exercise but do not contribute to solving the long-term integration of communications and information systems between NATO partners and establishing a NATO C2 architecture of integrated air and missile defense.[58] The RAND article, "Interoperability of U.S. and NATO allied Air Forces: Supporting Data and Case Studies" states that these work arounds are a result that can only be solved at the strategic level:

> Interoperability workarounds – used here to connote short-term and usually incomplete solutions to the interoperability problems that were encountered - and longer-term interoperability solutions need to address the fundamental sources of the problem. For example, no amount of operational, tactical, or technological workarounds can repair an interoperability problem whose origins are fundamentally at the strategic level.[59]

This challenge will only continue to grow as NATO countries continue to modernize their air defense artillery weapons systems:

> CIS interoperability can come in many forms, from sharing of exact equipment to having work-arounds with very disparate equipment. And the pace at which these technologies change, the markets in which they are purchased on a state-by-state basis, and the spread of modernization across nations make CIS interoperability a significant challenge.[60]

NATO and the United States are faced with a growing problem of technical integration as the focus on a regional air threat as discussed in national level strategic documents. NATO and the United States are burdened with an aging Link-16 infrastructure that is displaying limitations in latency and integration with end users that do not purchase the United States developed

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[57] Pernin et al, *Targeted Interoperability*, 7.

[58] Ackerman, "In NATO, Technology Challenges Yield to Political Interoperability Hurdles."

[59] Eric V. Larson, ed., *Interoperability of U.S. and NATO Allied Air Forces: Supporting Data and Case Studies* (Santa Monica, CA: RAND, 2003), xiv.

[60] Pernin et al, *Targeted Interoperability*, 44.

equipment. The technical integration of air defense artillery communications and information systems is not a problem inherent on its own. Technical integration is only one of the symptoms of a greater issue with interoperability between NATO and the US air defense weapons systems.

Foreign Disclosure Obstacles

The technical integration challenges of NATO and US air defense artillery weapon systems challenges is exacerbated by the restrictions on foreign disclosure and the willingness of allied nations to invest in interoperability, share security and industrial information. Work arounds and ad hoc measures have only served as a "band aid" to the larger interoperability issues that plague NATO and the United States. The foreign disclosure challenges that are limiting the development of interoperability between the United States and their NATO allies start at the strategic and national level. The US foreign disclosure policies, limited bilateral agreements coupled with allied partners governments and industry desire to share technical and security data is the starting point for interoperability roadblocks. The following section will discuss the foreign disclosure challenges serving as a roadblock for the NATO alliance of achieving the doctrinal definition of integrated air and missile defense.

The ability to digitally integrate communications and information systems must be done through a data sharing network such as Link-16. Link-16 and the hardware required to send, receive, and correlate that data falls under what is called Command, Control, Communications, Computer, Intelligence, Surveillance and Reconnaissance (C4ISR). The process that protects the data and those systems that transmit that data is called Information Security (INFOSEC) and the means to deny access to that data or network is called Communication Security (COMSEC). The Defense Security Cooperation Agency (DSCA) Policy 20-74, "Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Communications Security (COMSEC) Policy Update", provides the following definitions:

> *C4ISR:* C4ISR encompasses systems, procedures, and techniques used to collect and disseminate information. It includes intelligence collection and dissemination networks,

> command and control networks, and systems that provide the common operational/ tactical picture. It also includes information assurance products and services, as well as communications standards that support the secure exchange of information by C4ISR systems.
>
> *INFOSEC:* The protection of information systems against unauthorized access to or modification of information, whether in storage, processing, or transit, and against the denial of service to authorized users, including those measures necessary to detect, document and counter such threat.
>
> *COMSEC:* COMSEC is the measures and controls taken to deny unauthorized persons' information derived from telecommunications and other information systems, and technologies necessary to ensure the authenticity of such communications. COMSEC includes cryptographic security, transmission security, emissions security, and physical security of COMSEC material.

The DCSA policy letter 20-74, "Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Communications Security (COMSEC) Policy Update", defines what is considered classified and who the exchange may occur with:

> *Release of Classified Military Data:* Interoperable systems that exchange classified military information are subject to a disclosure review and approval as defined in National Disclosure Policy (NDP-1). In addition to classified system hardware and software information, all data flowing between foreign and secure U.S. C4ISR weapon systems is classified.
>
> *North Atlantic Treaty Organization (NATO), NATO member nations:* The release process for INFOSEC/COMSEC products is defined in CNSSP No. 8 (not for public release). INFOSEC/COMSEC products released to these member nations are governed by allied agreements. These, policies and procedures that describe the requirements by which the U.S can provide INFOSEC/COMSEC products, technical security material, information, and techniques. [61]

The Chairman of the Joint Chiefs of Staff Manual 5230.01A, "Joint Staff Foreign Disclosure and Foreign Visits Programs", defines foreign disclosure as, "[t]he process by which classified information is made available through approved channels to an authorized representative of a foreign government or international organization." [62] Classified US data,

[61] Defense Security Cooperation Agency, "Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Communications Security (COMSEC) Policy Update," January 11, 2021, accessed January 23, 2021, https://samm.dsca.mil/policy-memoranda/dsca-20-74.

[62] Department of Defense, Joint Staff, "Chairman of the Joint Chiefs of Staff Manual 5230.01A," December 21, 2017, A-1, accessed February 1, 2021,

equipment, material or information are not openly or freely released to all countries of an alliance. The United States has bilateral, multinational treaties or security agreements with nations within NATO but that is not a blanket agreement with all NATO members. These treaties and security agreements define what is shared between countries in the form of operational, access, financial, material, guarantees, and administrative/legal.[63] The exact agreements between the United States and specific NATO countries are not released to the public at this classification level. The RAND study, "U.S. Security-Related Agreements in Force Since 1955" identifies the top ten countries that the United States has entered into these type of security agreements or treaties with:

> The top ten partners when both bilateral and multilateral are considered (each with over 100 agreements, though not necessarily at the same time) include (in order) the United Kingdom, Canada, Germany, France, Italy, The Netherlands, Norway, Japan, Spain, and Belgium. [64]

Nine of the top ten security agreement aligned partners with the United States are NATO countries. Within the NATO alliance there are thirty countries with seventeen of those countries possessing air defense weapon systems and of the seventeen, only 6 possess the United States developed Patriot missile systems which is Link-16 capable. Though the Patriot missile systems are like systems, and the Multifunctional Information Distribution System (MIDS) that provides Link-16 capabilities are US developed and sold through Foreign Military Sales (FMS), the ability to integrate these systems are delayed due to US foreign disclosure policies:

> Some C4ISR equipment/systems may require additional interagency, service specific, or multi-national release approvals beyond the CNSSP No. 8 (not for public release) or CJCSI 6510.06 series (not for public release) processes. These systems include, but are not limited to: Multifunctional Information Distribution System Low Volume Terminals (MIDS-LVT), Link-22 Beyond Line of Sight Tactical Data Link (BLOS-TDL), GPS/PPS, and radio Waveforms. These additional release requirements may require

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https://www.jcs.mil/Portals/36/Documents/Library/Manuals/CJCSM%205230%2001.pdf?ver=tI2N9uC9JqSL7MqwwkFsjA%3d%3d.

[63] Jennifer Kavanagh, *U.S Security-Related Agreements in Force Since 1955* (RAND Corporation, 2014), xv.

[64] Ibid., xvi.

> additional time for release approval; therefore, early planning and coordination with the responsible CCMD is crucial during case development.[65]

The number of US developed air defense weapons systems in NATO makes up one-third of the air defense artillery weapon systems in NATO. The remaining two-thirds of the NATO country air defense artillery weapon systems do not possess MIDS technology, which prohibits their ability to connect in to the Link-16 network. The numerous air defense artillery weapon systems that are employed in NATO makes it almost impossible to integrate on a shared network due to policy restrictions:

> National interoperability and integration policies that imped the ability to achieve at least interoperability if not integration at the fire unit level must be developed. Trust and confidence in our Allies and Partners is required to ensure that weapon systems and operators can exchange sensor data, deconflict fires, prevent fratricide, use sensor data to detect, track, and cue threats, and prevent effector wastage.[66]

Strict policy guidelines serve to protect the sensitivity of data, material solutions, information from being accessed by foreign governments and potential threats. These policies also limit the free flow of information and the ability to integrate differing air defense weapon systems during operations and exercises. The very same policies that are established to protect, also counter the national policy guidance on enhancing interoperability and integration. The established foreign disclosure policies build walls instead of bridges between NATO and the United States when trying to increase air defense capacity through integration.

National Resourcing and Consensus

The political will to invest, share technologies and information to build an integrated air and missile defense network under the definition of interoperability is mentioned in United States and NATO strategic level guidance. As discussed in the literature review interoperability is

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[65] Defense Security Cooperation Agency, "Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Communications Security (COMSEC) Policy Update," January 11, 2021, accessed January 23, 2021, https://samm.dsca.mil/policy-memoranda/dsca-20-74.

[66] NATO Industrial Advisory Group, *NIAG SG-220 Study on GBAD Operations in the 21st Century*, J-2.

necessary for the United States and its NATO allies to be able to increase air and missile defense capacity against a regional threat. Though the desire for interoperability in the strategic guidance is clear, the resourcing and the political will appear to be disjointed among the NATO allies on the way forward. General Breedlove, states in the *Atlantic Council* article, "Toward Effective Air Defense in Northern Europe":

> One of the most urgent requirements is integrated air defense, an effort that will require investments at the national and NATO levels. This will necessitate close coordination to ensure that sensors, shooters, and command and control systems are available and aligned to provide layered air defense.[67]

Limited trust and the political desire to invest in a long-term comprehensive integrated air and missile defense plan is the final symptom that prevents the interoperability of United States and NATO allies air defense artillery weapon systems.

The concept of interoperability differs among the NATO allies at the strategic level which slows the ability to move forward. Luc Dini, Director of Business Development Missile Defense at Thales Air Systems, states in the *Europe's World* article, "Air and Missile Defense in Europe: Building a Consensus":

> With growing asymmetric threats, Europeans need to set aside their differences and find consensus on an integrated missile defense while preserving the sovereignty of their airspace and territory. The options are as many as the threats themselves, and are all facing intense financial pressures and lively debate.
>
> Coming to a final consensus on this issue requires a more balanced contribution between the U.S. and European nations, including from industry as well as through contributions to NATO collective funding.[68]

Short-term integration of air defense artillery weapon systems is a difficult challenge for exercises and operations at the tactical level through work arounds and ad hoc plans. The necessity for the strategic and national level consensus on integrated air and missile defense is absolutely the key in being able to achieve interoperability. European NATO nations and the

[67] GEN Phillip M. Breedlove, "Toward Effective Air Defense in Northern Europe," *Atlantic Council* (February 2018): 6.

[68] Luc Dini, "Air and Missile Defense in Europe: Building a Consensus."

United States have allied together since 1949 and once had an established air defense network to deter the Soviet threat. Without a certain or identified threat to NATO the debate over costly air defense artillery equipment and integrated C2 network versus the risk of not investing in integrated air and missile defense continue to be on the fore front of NATO consensus. The rapid modernization of technologies is expensive and vary in their capability to defeat the vast air threats. Without a defined enemy such as the Soviet Union, NATO consensus on air and missile defense remains severed.

The strategic decision to increase the capacity and capabilities of NATO integrated air and missile defense will be decided at the national level before NATO and the United States can move forward and commit to any unified modernization. The level of technology advances in C2 and air defense artillery weapon systems between the NATO countries varies from the United States leading with the most technical advanced equipment to the NATO nation that has a 30mm air defense artillery gun. The decisions made at the national level will direct where the defense or military funds are going to be spent. The RAND article "Targeted Interoperability" states,

> Hardware can vary widely among typical partners, where some might have analog radios and no common picture in their headquarters, and others like the United States might have high-end digital communications equipment and sophisticated (and proprietary) command and control software. And even if the hardware is common - like having the same digital radios from a given manufacture - those units may not be able to speak if the underlying security keys are not similar. Big impediments to CIS interoperability are cost (of advanced CIS equipment), which will limit overall abilities, and policies for sharing specific data and crypto keys for secure communications. These are exacerbated by the rapidity at which CIS system technologies progress, which puts additional costs and policy hurdles as ongoing challenges.[69]

As the technologies become more advanced due to modernization of air defense artillery and C2 equipment the desire of individual countries and industry to protect that information grows. As discussed, foreign disclosure policies are a roadblock and a symptom to the greater challenge of integration and interoperability.

[69] Pernin et al, *Targeted Interoperability*, 45.

European NATO countries and industry want to depend on European based industries to modernize the air defense artillery inventory for European countries. The inherent issue is the US strict policies on foreign disclosure and information sharing. The challenge to develop and integrated C2 network is extremely challenging when trying to overcome European pride in industry and the US restrictive foreign disclosure policies:

> National pride leads most nations to favor indigenous military procurement of C4I systems, which reduces the likelihood that multinational systems will readily operate with U.S. systems....The United States places many restrictions on the types of information it is willing to share with certain coalition partners, but it is difficult to develop interoperable information systems that allow only selective passage of information. Multiply this requirement by the number of nations involved and the difficulty of building interoperable systems becomes overwhelming.[70]

The adverse effect of not developing an integrated network that is a free share of information will only continue to isolate lower income NATO countries that cannot afford nor have the desire to keep pace with the modernization of C2 networks and air defense artillery equipment. Technical integration challenges, INFOSEC policies, and cost could possibly drive the United States to pursue its own solution to integrated air defense in the European theater without NATO financial support or consensus.

Cost burden sharing among the NATO alliance helps increase capacity and capability of limited resources. NATO and the United States are at a crossroads with strategic and national level decisions whether to develop and air defense C2 network, modernize its air defense artillery weapons systems or just accept the status quo. Without European NATO country consensus and the US strict foreign disclosure policies, integrated air and missile defense may never achieve interoperability as described in the literature review and as directed in national level guidance.

> Further, because the United States is largely able to go it alone if necessary, NATO allies may view interoperability efforts as a one-way street, with interoperability compromises and costs unfairly forced on them. Their response might be to accept less well-integrated

[70] Ibid., 45.

> interoperability levels with the expectation that the United States will ultimately absorb the costs of coalition interoperability shortfalls and inefficiencies.[71]

The scenario provided above from the RAND article "Targeted Interoperability" is the opposite direction in how the United States and NATO should move forward in integrating air defense weapons systems.

Conclusion

The collapse of the Soviet Union not only changed the political landscape of Europe and the world but also changed the way NATO would prepare for future threats from the air domain. NATO abandoned its integrated air defense architecture in the early 1990s only to pursue an integrated ballistic missile defense program that was initiated through the European Phased Adaptive Approach. Due to technical and foreign disclosure obstacles, NATO and the United States do not have a unified data architecture that is capable of integrating NATO and US air defense artillery weapons systems without ad hoc work arounds. These work arounds are successful for the short-term exercises but do not assist in forcing a change towards a long-term solution of integration. A holistic NATO data architecture must be developed that allows for a plug-and-play type integration among the NATO allies. A joint endeavor between European and US industry is the only way to achieve success in developing a link architecture that NATO and the United States will be willing to invest into. Duane Neal, Associate at Booz Allen Hamilton, summarizes the fragile relationship between foreign military sales and policy change, "Integration of U.S. and allied partner capabilities requires more than foreign military sales. It also requires mutual agreements in security cooperation and concept of employment, such as responsibility for action or conditions which warrant using various levels of military power."[72] Short-term fixes

[71] Myron Hura et al., *Interoperability: A Continuing Challenge in Coalition Air Operations* (Rand Corporation, 2000), 11, https://www.rand.org/pubs/monograph_reports/MR1235.html.

[72] Duane Neal, "Succeeding at Integrated Air and Missile Defense," *Booz Allen Hamilton* (n.d.): 4.

through work arounds at the tactical level are currently where NATO and the United States have the ability integrate their medium-low air defense weapons systems on the battlefield.

The feasibility of NATO and the United States achieving integration and interoperability at the tactical, operational, and strategic level to develop a NATO integrated air and missile defense shield against a regional threat is severely challenged at the strategic level. The strategic and national level guidance address the advantages of integration and interoperability with their NATO allies but fail to enforce those beliefs. The guidance on interoperability is clear, yet the foreign disclosure policies and the resources available to fully integrate with NATO allies is extremely challenged through the restrictive measures the United States places on its technology and information sharing.

The high cost of air defense artillery weapons systems makes the idea of increasing capacity and capability through burden sharing between the United States and NATO an attractive solution for capacity shortfalls. However, until NATO and the United States can come to a consensus on a holistic integrated data network, allies' sensors and shooters will be stove piped and ineffective to defeat an air threat from a regional adversary. Finally, the United States either must re-examine its foreign disclosure policies on the integration of allies into a fully integrated network, or be prepared to fight the next air threat on the battlefield alone.

Bibliography

Ackerman, Robert. “In NATO, Technology Challenges Yield to Political Interoperability Hurdles.” *Signal* (February 2006). Accessed December 14, 2020. https://www.afcea.org/content/nato-technology-challenges-yield-political-interoperability-hurdles.

Air and Missile Defense Integration Division, USASMDC. *Army Air and Missile Defense 2028*, March 2019.

Breedlove, Phillip M. “Toward Effective Air Defense in Northern Europe.” *Atlantic Council* (February 2018): 7.

Cioca, Florian. “Perspectives on Interoperability Integration Within NATO Defense Planning Process.” *Journal of Defense Resources Management* 29, no. 2 (2011): 13.

Department of Defense, Joint Staff. “Chairman of the Joint Chiefs of Staff Manual 5230.01A,” December 21, 2017. Accessed February 1, 2021. https://www.jcs.mil/Portals/36/Documents/Library/Manuals/CJCSM%205230%2001.pdf?ver=tI2N9uC9JqSL7MqwwkFsjA%3d%3d.

Defense Security Cooperation Agency. “Command, Control, Communications, Computer, Intelligence, Surveillance, and Reconnaissance (C4ISR) and Communications Security (COMSEC) Policy Update,” January 11, 2021. Accessed January 23, 2021. https://samm.dsca.mil/policy-memoranda/dsca-20-74.

———. *Description of the National Military Strategy 2018*. Washington, DC: Department of Defense, n.d.

Dini, Luc. “Air and Missile Defense in Europe: Building a Consensus.” *Friends of Europe* (April 1, 2015). Accessed December 19, 2020. https://www.friendsofeurope.org/insights/air-and-missile-defence-in-europe-building-a-consensus/.

Freedberg, Sydney J. Jr. “Achilles Heel of Army Air and Missile Defense: The Network.” *Breaking Defense* (February 15, 2017). Accessed January 16, 2021. https://breakingdefense.com/2017/02/achilles-heel-of-army-air-missile-defense-the-network/.

Headquarters, Department of the Army. *Army Regulation 34-1, Interoperability*. Washington, DC: Government Printing Office, 2020.

Headquarters, and Department of the Army. *FM 3-01 US Army Air and Missile Defense Operations*. Washington, DC: Government Printing Office, 2020.

Hura, Myron, Gary McLeod, Eric Larson, James Schneider, and Daniel Gonzales. *Interoperability: A Continuing Challenge in Coalition Air Operations*. RAND Corporation, 2000. Accessed December 4, 2020. https://www.rand.org/pubs/monograph_reports/MR1235.html.

Judson, Jen. “Capacity, Interoperability Still Plague Europe Missile Defense.” *Defense News* (July 31, 2017). Accessed December 17, 2020.

https://www.defensenews.com/smr/european-balance-of-power/2017/07/31/capacity-interoperability-still-plague-european-missile-defense/.

Kavanagh, Jennifer. *U.S Security-Related Agreements in Force Since 1955*. RAND Corporation, 2014.

Kongsberg Defense and Aerospace. "NASAMS Air Defense System." Last modified August 2019. Accessed January 13, 2021. https://www.kongsberg.com/globalassets/kda/products/defence-and-security/integrated-air-and-missile-defence/nasams-air-defence-system/19_08_2019-brosjyre-nasams-air-defence-system.pdf.

Larson, Eric V., ed. *Interoperability of U.S. and NATO Allied Air Forces: Supporting Data and Case Studies*. Santa Monica, CA: RAND, 2003.

Machi, Vivienne. "NATO Missile Defense Systems Strive for Interoperability," *National Defense* (July 31, 2017): 9. Accessed December 21, 2020. https://www.nationaldefensemagazine.org/articles/2017/7/31/nato-missile-defense-systems-strive-for-interoperability.

Mann, David L., Roger F. Mathews, and Francis G. Mahon. "'None of This Is Going to Matter If You're Dead': Modernizing Integrated Air and Missile Defense Must Remain Army's Top Priority." *Real Clear Defense* (June 16, 2020). Accessed December 17, 2020. https://www.realcleardefense.com/articles/2020/06/16/none_of_this_is_going_to_matter_if_youre_dead__modernizing_integrated_air_and_missile_defense_must_remain_armys_top_priority_115381.html.

Mattis, Jim. *Summary of the 2018 National Defense Strategy*. Accessed December 16, 2020. https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf.

NATO Industrial Advisory Group. *NIAG SG-220 Study on GBAD Operations in the 21st Century*, October 2019.

NATO Public Diplomacy Division. "2016 NATO BMD Fact Sheet." NATO, July 2016. Accessed February 6, 2021. https://www.nato.int/nato_static_fl2014/assets/pdf/pdf_2016_07/20160630_1607-factsheet-bmd-en.pdf.

NCI Agency. "NATO's Ballistic Missile Defense Program Gets a Makeover." Last modified November 25, 2019. Accessed January 5, 2021. https://www.ncia.nato.int/about-us/newsroom/natos-ballistic-missile-defence-programme-gets-a-makeover.html.

Neal, Duane. "Succeeding at Integrated Air and Missile Defense." *Booz Allen Hamilton* (n.d.): 4.

Office of The Secretary of Defense. *Missile Defense Review*, 2019. Accessed January 19, 2021. https://www.defense.gov/Portals/1/Interactive/2018/11-2019-Missile-Defense-Review/The%202019%20MDR_Executive%20Summary.pdf.

Pernin, Christopher G., et al. *Targeted Interoperability: A New Imperative for Multinational Operations*. Research report RR-2075-A. Santa Monica, CA: RAND Corporation, 2019.

Pronk, G.W. “The Importance of Integrated Air and Missile Defense Training.” *The Journal of the Joint Air Power Competence Centre* 30 (Spring/Summer 2020): 78–84.

Raytheon. *Missile Defense Update: Keeping Europe Safe*, May 2018. Accessed December 15, 2020. https://www.raytheon.com/sites/default/files/2018-05/European%20Missile%20Defence%20Update_May2018_0.pdf.

Tolk, Andreas. “Beyond Technical Interoperability” (June 2003): 24. Accessed January 6, 2021. https://apps.dtic.mil/sti/pdfs/ADA466775.pdf.

Trump, Donald. *National Security Strategy of the United States*. Washington, DC, December 2017.

US Department of Defense, Joint Staff. *Joint Publication (JP) 3-01 Countering Air and Missile Threats*. Washington, DC: Government Printing Office, 2017.

Williams, Ian. “Aegis Ashore.” *Missile Threat, CSIS Missile Defense Project* (April 14, 2016). Accessed January 9, 2021. https://missilethreat.csis.org/defsys/aegis-ashore/.

Williams, William B., Virginia W. Perry, and Harold F. Candy. *NATO Standardization and Interoperability - Handbook of Lessons Learned:* Fort Belvoir, VA: Defense Technical Information Center, December 1, 1978. Accessed December 28, 2020. http://www.dtic.mil/docs/citations/ADA065634.

Zanini, Michele, and Jennifer M. Taw. *The Army and Multinational Force Compatibility*. Santa Monica, CA: RAND, 2000.