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Future Approaches to Red Air Delivery in NATO Air Forces in 5th Generation Fighter Training

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SUBJECT:
Future Approaches to Red Air Delivery in NATO Air Forces in 5th Generation Fighter Training

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With the transition to smaller fleets of more capable 5th Generation fighter aircraft, NATO nations are challenged to maintain fighter proficiency while simultaneously supplying credible Red Air threat replication. This problem stems from the limited pool of pilots and aircraft available, but is exacerbated by the growing complexity and size of potential adversaries and the requirement to train 5th and 4th Generation integration rather than utilizing 4th Generation resources to train 5th Generation forces.

A broad range of options exists to provide future Red Air capabilities, some of which have the potential – in the long term – to reduce the flying requirement for live Red Air aircraft and pilots. These include simulators, Live/Virtual/Constructive (LVC) environments, Augmented Reality (AR), Unmanned Aerial Systems (UAS), and different delivery models for aggressor forces, including contracted Red Air.

However, none of these options – with the exception of contracted Red Air or future Red Air UAS – are capable of replacing the benefits of in-flight training against a live adversary aircraft. At the same time, there are downsides to live flight training that can only be mitigated by developing capable alternative training environments and methodologies. There are few ranges large enough – and none secluded enough – to conduct unrestricted training against the expected number of opposing aircraft, missiles, and electromagnetic operations at appropriate distances to train the entire scope of required capabilities. Finally, there are promising technological advances like AR, Artificial Intelligence (AI), and Machine Learning (ML) that could someday bring the benefits of virtual environments into live aircraft.

Therefore, this study intends to move the conversation forward, recognizing the current challenges, both technological and economic, so that optimal training of NATO 5th and 4th Generation aircraft can be faced efficiently. There is no single solution across the Alliance but some proposals are offered in this study.

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EXECUTIVE SUMMARY

Red Air is a significant part of the NATO fighters training. However, this function is increasingly tricky for NATO countries to carry out, especially individually, due to the associated costs and the lack of materiel and personnel resources.

These costs raise the following question: How to maintain fighter proficiency while simultaneously supplying a credible Red Air training adversary? This question challenges NATO nations as they integrate 5th Generation fighter aircraft into their forces.

With reduced aircraft and pilot availability, traditional Red Air models are no longer an affordable option to effectively train NATO air forces. Furthermore, there are downsides to live-flight training that require mitigation by developing capable alternative environments and methodologies. Therefore, NATO nations must pivot their training model to incorporate a broad range of existing opportunities and emerging technologies to improve future Red Air capabilities, including in-flight training against live adversary aircraft.

To coordinate all these technologies and efforts, an International Red Air Standards Branch in close coordination with analogue National Branches and a NATO Aggressor Unit should be the core of a new training model. Furthermore, other areas such as Airborne Early Warning or Ground Controllers may be included in future studies.

This new model would provide the basis for standardization among the nations, increase the quality of training, and reduce the overhead of running a unit-level program. Furthermore, this model could solve both the knowledge and materiel gaps faced by the nations and improve tactical and strategic training.

This study intends to foster dialogue between community experts on how to provide this credible and sustainable Red Air training while offering different proposals. These proposals incorporate all available and known future technologies to improve adversary training, ultimately increasing unit combat readiness.

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CHAPTER 1

A JAPCC Study of Requirements, Opportunities, and Challenges

1.1 Introduction

As nations integrate 5th Generation aircraft into their Air Forces, they find themselves in a world where the cost per unit and associated maintenance costs have dramatically shrunk their aircraft fleets. Clear examples are Norway which is replacing 56 F-16 Mid-Life Update (MLU) (from the original 74 F-16A) with 52 F-35As; The Netherlands, which is replacing 68 F-16MLU with 46 F-35As; and Belgium, which will replace its 54 F-16MLU with 34 F-35As. As many NATO nations are initiating 6th Generation projects, further downward pressure on the size of European fighter fleets is expected.

While it is true that the newest generation of aircraft is much more capable than previous generations and are designed to perform more complex missions, success against a near-peer adversary will require the integration of all available fighter forces.

Additionally, with the drawdown in fleets, there has been a reduction in the number of pilots. In some cases, this has simply been due to aircraft-to-aircrew ratios, but economic pressures and the growth of civilian airlines and the travel industry have also impacted military pilot manning. Moreover, for this smaller cadre of pilots in NATO squadrons, the administrative and

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leadership workload has increased and now significantly influences their flying activities. This puts a higher premium on the usefulness and relevance of each generated training sortie.

Furthermore, as the aircraft and crew numbers across NATO decrease, fewer aircraft are available to fill the Red Air role. Increasingly, NATO Air Forces rely on their most capable operational 4th Generation aircraft, and even new 5th Generation aircraft, in Red Air roles to simulate adversary aircraft, tactics, and armament. However, as 4th and 5th Generation aircraft are expected to operate and train as a combined force for years to come, NATO Air Forces cannot afford to continue employing their limited 4th and 5th generation fighting force as Red Air. In addition, as Red Air missions are flown by the same, already reduced number of pilots, who need Blue training sorties, the cost of Red Air missions flown is proportionally higher for each 4th Generation pilot. Finally, as the missions are getting more complex due to the necessity to simulate adversary cutting-edge tactics and technologies, the costs of training missions are increasing. This situation alone makes it necessary to adjust the nations' training models.

The technological advances made by potential adversaries only make this problem worse. The nations must now prepare for even more sophisticated weapon systems, augmented by a network of air defences integrated across domains – air, land, maritime, space, and cyber – designed to contest NATO forces' operational access. Furthermore, potential adversaries have also ongoing projects for stealth bombers, stealth drones, and stealth cruise missiles that will augment the 5th Generation fighters they are just now beginning to field. As export versions of these weapon systems are developed, the number of possible near-peer adversaries will also grow.

Recognizing the complexity of this threat and the constraints on operational and training resources, NATO's 2018 Joint Air Power Strategy stated: 'Future training environments must take advantage of technological advances to balance live, virtual and constructive opportunities and exploit the potential to permit persistent synthetic training in complex environments.'[1]

The 2018 Framework for Future Alliance Operations (FFAO) also identified requirements to facilitate training and simulation in all areas, experiment and test new systems, reduce cost and environmental impact, and increase realism. The ability to conduct training and exercises, which increasingly integrate emerging technologies (like AI, human augmentation, or autonomous systems) into virtual environments and all military disciplines, is also required.[2]

These requirements should be considered when developing future training concepts and new employment doctrines alike.

It should also be noted that there have been efforts to resolve the shortage of Red Air within the Alliance. The European Air Group (EAG) began an initiative under the Combined Air Interoperability Programme (CAIP) for Red Air within NATO in 2017. The main output thus far has been the Harmonized European Red-Air Means Exchange System (HERMES) tool, which operates under the umbrella of the Air Transport & Air-to-Air Refuelling and other Exchanges of Services (ATARES) Technical Agreement (TA) to allow NATO Air Forces to exchange Red Air services. Although it allows nations to obtain ATARES hours compensation for their services, the problem remains the same. There are fewer fielded aircraft and pilots, and they need Blue Air training more than ever. Moreover, when most of NATO's Air Forces have migrated to 5th Generation only, there will be even less capability to offer up for trade.

Notwithstanding these challenges, the nations must be imaginative and look for new and common solutions to provide the best possible training to prepare NATO Air Forces for near-peer threats without compromising either 4th or 5th Generation aircrew training. A new training model with the employment of the latest technologies in combination with the traditional Red Air systems and with the most updated tactics is needed to develop pilot and C2 systems capabilities and challenge the Air Forces.

1.2 Aim

This study aims to provide recommendations for optimizing Red Air capability and training in order to offer the most efficient and effective training for legacy, 5th Generation, and future aircraft.

1.3 Assumptions and Prerequisites

Research and analysis associated with this study includes open sources, collaboration with JAPCC Combat Air Branch SME's, and interviews with SME's from the European Defence Agency (EDA), EAG, and the United States (US) Air Force 64th Aggressors Squadron from Nellis Air Force Base. To avoid discussing the specifics of 'aircraft generations' (such as 3rd, 4th, and 5th or even 6th) in this report, 'legacy aircraft' refer to aircraft that were not designed and manufactured with a primary focus on creating a very low radar signature ('stealth'). This study was kept at the unclassified level to allow for potential dissemination. Where classified sources were examined, only unclassified information was extracted.

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CHAPTER 2

Red Air Background

2.1 Introduction

Historically, NATO nations provide Red Air using two primary approaches. One approach employs dedicated and specialized aggressor forces as Red Air, whereas most national approaches rely solely on fighter squadrons to provide their own Red Air support. This chapter provides background on these approaches.

The US Air Force and US Navy first established specialized air-to-air aggressor squadrons to combat the unacceptable loss rate in the Vietnam War.[1] The 64th AGRS, the first air-to-air aggressor squadron, was established with excess Northrop T-38 Talons but soon acquired Northrop F-5E Tiger aircraft to simulate the small, supersonic MiG-21 in air combat manoeuvres.[2] Air Force leadership deemed the training so useful that they established a second squadron, the 65th FWS, at Nellis Air Force Base and two additional units for overseas training. Underpinning these squadrons are aggressor pilots and dedicated controllers, who are all experienced operators, trained and evaluated in adversary weapons and tactics, and integrated with intelligence experts to ensure credible adversary replication. Since their inception, specialized Aggressor Squadrons have played a crucial role in training all US fighter squadrons in major exercises (i.e., Red Flag), at the service Weapons Schools, and through dissemination of adversary weapons and tactics standards for US fighter units to employ when providing their own Red Air. However, US Aggressor Squadrons have never replaced the requirement for fighter squadrons to provide their own Red Air during home-station training.

With few exceptions, most NATO Air Forces have entirely relied on operational or training squadrons to provide Red Air. These squadrons generally lack specialization and training in Red Air weapons and tactics and are incapable of fully replicating the adversary. Compounding this lack of specialization, the large international exercises where NATO forces train together tend to use open-source, unclassified adversary weapons parameters and tactics to protect individual nations' insights into adversary capabilities. No standardized adversary weapons and tactics guide exists within NATO, and there is no overarching approach to ensuring the quality of Red Air within the Alliance.

The lack of standardized adversary tactics was not insurmountable when NATO forces were large, and adversary tactics were relatively simple with dependence on Ground Controlled Intercept (GCI) and supported by single-digit Surface-to-Air Missiles (SAM). However, as adversary capabilities and tactics have advanced, NATO squadrons are no longer capable of training in executing their tactics while simultaneously preparing credible methods to replicate adversaries. The complexity of modern adversary capabilities makes it inefficient for individual nations and fighter squadrons to develop their own Red Air standards. There are not enough pilots to share the workload without affecting unit readiness. Moreover, even for nations with dedicated aggressor forces, the burden of providing Red Air training within fighter squadrons has become unsustainable due to the smaller number of pilots and lower aircraft availability.

2.2 4th Generation Training

Since the dissolution of the Warsaw Pact and the end of the wars in Bosnia Herzegovina and Kosovo, NATO Air Forces have not faced a peer rival in the air. Furthermore Global War on Terrorism operational requirements have emphasized low-threat Close Air Support (CAS) operations instead of Offensive Counter Air (OCA) and Defensive Counter Air (DCA). For an entire generation of fighter pilots, air-to-air training started from the presumption of assured Air Superiority, if not Air Supremacy, and always assumed adversaries possessed lesser capabilities. The air environment was considered a sanctuary. While Russia and China gradually increased their capabilities, NATO exercises and the daily training for most nations remained unchanged until the Anti-Access/Area Denial (A2/AD) problem was acknowledged. In this context, daily training and exercises have generally been executed against outnumbered Red Air, with semi-active missiles and moderate coordination with single-digit SA systems. Only occasionally were adversaries with active missiles in highly demanding SA scenarios considered.

However, with the recognition of the A2/AD problem, NATO Air Forces have acknowledged the changed threat environment and attempted to increase the number and quality of Red Air during exercises and training, either by increasing adversary aircraft, replicating more capable weapons, using less restrictive Red Air regeneration requirements, or by introducing the more ominous double-digit SA systems. Towards this end, the US Air Force has created an Air Defence Aggressors Squadron and reactivated the 65th Aggressors Squadron with 5th Generation aircraft.[3] However, neither of these squadrons is capable of providing training to all exercises or fighter units at their home stations.

Major NATO exercises now tend to approach the Red Air requirement from a more comprehensive approach. They still depend on operational aircraft to augment or replace professional aggressors but now utilize complex documentation such as Intelligence scenarios, Special Instructions (SPINS), or Standard Operational Procedures (SOPs) to compensate for the lack of NATO Red Air standards. While this has improved the quality of Red Air presentations to some degree, the complexity of the roles – and even the requirement to operate from different bases at times – has made it difficult to swap between Red and Blue roles during these exercises. As a result, NATO nations have had to reduce the number of aircrew trained in order to improve the replication of adversary capabilities.

This negative trend also plays out at the Tactical Leadership Programme (TLP), which is NATO's premier tactical training course. During a TLP course, Red Air is

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provided by the participating nations, which is also used as a familiarization for future students. While this has some benefits – experience with the airspace, training rules, scenarios, TLP planning, briefings, and debriefings – the nations still struggle to provide the required number of adversary aircraft and pilots. Even curtailed from three to two weeks, nations are still reluctant to send two to four additional aircraft and pilots to execute just one mission per day.

2.3 5th Generation Training

All the challenges with Red Air training carry over into NATO's 5th Generation forces. Their low-observable design and information fusion capability create additional challenges for aggressors replicating more capable and advanced threats with legacy systems.

5th Generation aircraft are designed to operate in contested environments where enemy air defences are tightly integrated with electromagnetic warfare capabilities. Their low-observable features and very capable sensors enable pilots to acquire and maintain considerable situational awareness far beyond those of legacy platforms. Self protection is also dramatically improved, denying or degrading an opponent's ability to detect, track, and engage the aircraft.

However, the small payload of the F-35 has driven many nations to maintain legacy aircraft capable of employing larger weapons loads. With its passive AN/AAQ-37 Distributed Aperture System (DAS), the F-35 can detect modern airborne and surface threats without compromising its own electromagnetic signature. Therefore, it can get much closer to aerial- and ground-based threats than legacy aircraft and can covertly transfer target data to the latter, potentially taking over guidance of their AMRAAM/Meteor missiles once launched at a greater distance from the threat, greatly enhancing the potential lethality and survivability of legacy aircraft.

All these capabilities derive from the foreseen and increasing threat diversity, but Red Air replication must also increase its capability to challenge 5th Generation fighters and 5th–4th Generation teaming. More complex Red Air concepts should include significantly higher numbers of Red Air assets, including 5th Generation/stealth threats, complex Electronic Warfare (EW) and SAM threats, and must be constructed to anticipate the challenges brought forth with the arrival of 6th Generation assets. Due to the limited availability of resources, either material and human, this is simply not possible with the traditional, squadron-based Red Air approach.

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3. Jamie Hunter, 'New Aggressor Squadron at Nellis Air Force Base will have both F-16s and F-35s', In: The Warzone, available from: https://www.thedrive.com/the-war-zone/37350/the-air-forces-new-aggressor-squadron-will-have-both-f-16s-and-f-35s, October 2020.

CHAPTER 3

The Strategic Context

3.1 Introduction

This chapter aims to identify trends and the most significant challenges shaping the strategic context to provide a broad view of the future operating environment in which NATO Air Forces might operate.

3.2 Global Security Environment

NATO is in its eighth decade and faces new strategic and institutional challenges. Unpredictable and demanding security environments generate steady potential for confrontation and conflict. The security environment around the Euro-Atlantic region has become more volatile due to threats and instability from the east and south. Recent events re-emphasize the importance of territorial integrity and the traditional roles of deterrence and defence, with a particular focus on collective defence.

As we are witnessing in Ukraine, future conflicts could range from hybrid wars to selective or full-scale military operations by major powers. For selective or hybrid wars, the objectives are likely to be specific and limited and will be achieved by the use of selected elements of power.[1] Regional conflicts and proxy wars, such as in Syria, Iraq, the Sahel, and the Horn of Africa, are expected to increasingly threaten global peace and security. Due to a global trend of population consolidation and the increasing number of mega-cities, the likelihood of future conflicts taking place in an urban environment is also high. From a political perspective, Euro-Atlantic relations and Alliance's cohesion is challenged if Europe does not assume a greater role in the security arrangement. The present level of European military dependency on the US is likely to continue, and NATO is expected to remain the key security Alliance for the Euro-Atlantic region.[2] However, the US global commitments are likely to mean that the Alliance's European members will have to assume more of the regional security burden and an increased presence in Africa and the Middle East.[3] At the same time, growing nationalism and divergent threat perceptions within NATO may cause Euro-Atlantic countries to look inwards and favour national solutions for security problems.[4] This divergence may cause the Allies' defence priorities to shift, which could further challenge the cohesion of the Alliance.

As the role of private actors providing security increases, many military functions and activities could be outsourced. In addition, new and emerging technologies offer enormous opportunities, but also present new vulnerabilities and challenges. The disproportionate rates of technological development amongst Alliance nations will exacerbate already existing compatibility issues and could jeopardize effective interoperability.

Simultaneously, many legal and ethical issues linked to prolific technical advancements will need to be solved. Exploiting state-of-the-art technology will require a change in defence and security organizations' acquisition and life-cycle management processes. Easy access to advanced technologies, which can be employed innovatively as weapons or in support of weapons, will continue to enable the disruptive behaviours of smaller states and non-state actors. NATO's reliance on space-based communications and navigation systems will also continue to expose the Alliance to vulnerabilities.[5] Adaptive A2/AD tactics counter technological advances, which modern tactics, techniques, and procedures leverage and depend upon to increase lethal effectiveness. The legacy skills of navigation, targeting and weapons employment merit further investigation as a way to combat technological vulnerabilities. Otherwise, continued development of resilient systems remains the priority solution to advancing counter technologies.

From the budgetary perspective, national levels of ambition should be aligned with fiscal realities and constraints. Defence expenses reflect changing government priorities.[6] Many nations specialize in specific military capabilities and rely on collaborative partnerships to meet their defence requirements while managing costs. This can help mitigate potential critical shortfalls in national capabilities to accomplish national tasks and ambitions but requires interdependence among sovereign states that may be difficult for some nations to accept.

3.3 Significant Challenges

NATO's adaptability to new challenges derives from its institutional structure, as well as mechanisms employed by agents and principals in a complex delegation relationship.[7] Institutional uncertainties remain over strategic issues concerning the distribution of resources, costs, and power within the Alliance.

Struggles between global powers continue to be important. The Russian invasion of Ukraine, the recent confrontation between North Korea and the US over Pyongyang's nuclear programme, the Iran nuclear deal, the advancing nuclear modernization programmes around the world, the India-Pakistan nuclear arms race, and China's increasingly assertive stance towards Taiwan, are all clear examples of potential sources for future conflict.

Many factors such as asymmetric demographic changes (i.e., increasing urbanization and polarized societies), easy access to emerging technologies, and economic and resource globalization have increased the potential for global strategic insecurities. Additionally, pandemics such as the SARS-CoV-2 virus (COVID19) have shown how quickly diseases can affect national and global economies, as well as change international relationships. As a result, some nations and global regions have pulled closer while rifts have arisen between others.

NATO partners, as well as the institution itself, face challenges from Russia that cross diverse areas, such as the territorial status quo, energy security, cyber security, and counter-terrorism. At the 2019 London Summit, the Heads of State and Government clearly summarized this environment: 'We, as an Alliance, are facing distinct threats and challenges emanating from all strategic directions. Russia's aggressive actions constitute a threat to Euro-Atlantic security; terrorism in all its forms and manifestations remains a persistent threat to us all. State and non-state actors challenge the rules-based international order. Instability beyond our borders is also contributing to irregular migration. We face cyber and hybrid threats.'[8]

In addition to the world's constant change and Russia's resurgence, for the first time, the Secretary General also addressed that the rise of China poses challenges for Alliance's security and stressed that 'as the world changes, NATO will continue to change'. Over the last decade, powerful state actors from the East (mostly Russia and China) have developed and refined robust military capabilities in the traditional domains of land, maritime, air, and space to deter opposing forces. Information operations, strategic and long-range air operations, advanced integrated air defence systems, precision strike capabilities from air, land, and sea weapons systems, and very low-observable multipurpose platforms could be considered major components of their arsenals, all of which can be networked and directed through centralized Command and Control (C2).

The A2/AD term can be used to describe the operational concept that uses a cluster of highly capable military systems combined and overlapped to create heavily defended 'bastions', into which it is extremely difficult for outside forces to gain access. Even though A2/AD is often presented as a defensive capability, these same capacities can also be employed in conducting or supporting offensive operations. Today, there are 'A2/AD bastions' in the Asia-Pacific region[9] as well as on NATO's eastern and south-eastern flanks, in Kaliningrad, Crimea, and Syria.[10]

It is also important to note that modern warfare is increasingly reliant on data, particularly from sensors through space. Because of the expansion of their military operations (both in terms of geography and precision strike information requirements), Russia and China have developed a significant constellation of satellites with capabilities similar to those of the NATO nations.[11] Their military space capabilities are key components of strategic deterrence. It is apparent that the space domain can be used to support and strengthen Command and Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) capabilities. Therefore, it is likely that state actors will continue to develop and modernize their space capabilities for military purposes.

Because the Electro-Magnetic Environment (EME) bridges the geophysical, space, and information environments, success in EME operations is often a precursor to success in the other operating domains. Indeed, EW will remain a force enabler and multiplier in future conflicts. Russia has consistently invested in EW modernization since 2009, with modernized EW systems entering service across the strategic, operational, and tactical levels.[12] At the same time, China is improving its EW capabilities, which they see as critical components of strategic deterrence and essential to fighting modern, information technology-enabled warfare.[13]

Although the EW assets of both Russia and China are under joint C2, many of these systems are deployable in Unmanned Aircraft Systems (UAS), rendering them low observable, highly mobile, and agile, which limits adversaries' ability to target and neutralize them. The aforementioned EW systems may not only provide electronic attacks but might also support Russian and Chinese C4ISR. These EW assets are often an integral part of A2/AD configurations, bridging and linking the geophysical and space domains, in particular for Signals Intelligence (SIGINT), air defence, and precision strike operations.

It is also highly likely that Russian and Chinese EME operations will fuse with cyber operations, allowing EW forces to corrupt and disable computers and networked systems as well as disrupt the use of the electromagnetic spectrum. In particular, NATO must acknowledge that Russia and China have integrated their EME capabilities within all domains of operations, and they may exploit the electromagnetic spectrum throughout all types of operations, including asymmetric and hybrid conflicts.

Similarly, emerging technologies, the exploration opportunities created by climate change, and the constant demand on energy resources contribute to the Arctic region becoming increasingly open to a range of activities such as oil, gas, and mineral exploration. These uncertainties increase the likelihood of future military intervention.

3.4 Conclusion

As NATO continues to perform its mission,[14] the Russian invasion of Ukraine and other factors such as increased polarization, power politics and competition, cyber-attacks and other non-attributable hostilities from state and non-state actors impact global security, further deepening uncertainty, disorder, and complexity.

While NATO nations' budgets are constrained, powerful adversary state actors have developed and refined robust military capabilities in all domains of operations, including 'A2/AD bastions', EME operations and EW. Therefore, NATO and its member nations must provide the most appropriate training for the new 5th Generation aircraft, but also for the current 4th Generation aircraft, and assure proper integration of the future 6th Generation aircraft.

To ensure that respective NATO aircrews can operate in this challenging environment and against new and advanced fighters, efficient solutions to the NATO Red Air problem must be found. This includes, but is not limited to, new technologies, conventional Red Air and also the use of private providers or the specialization of specific military capabilities or collaborative partnerships between specific nations.

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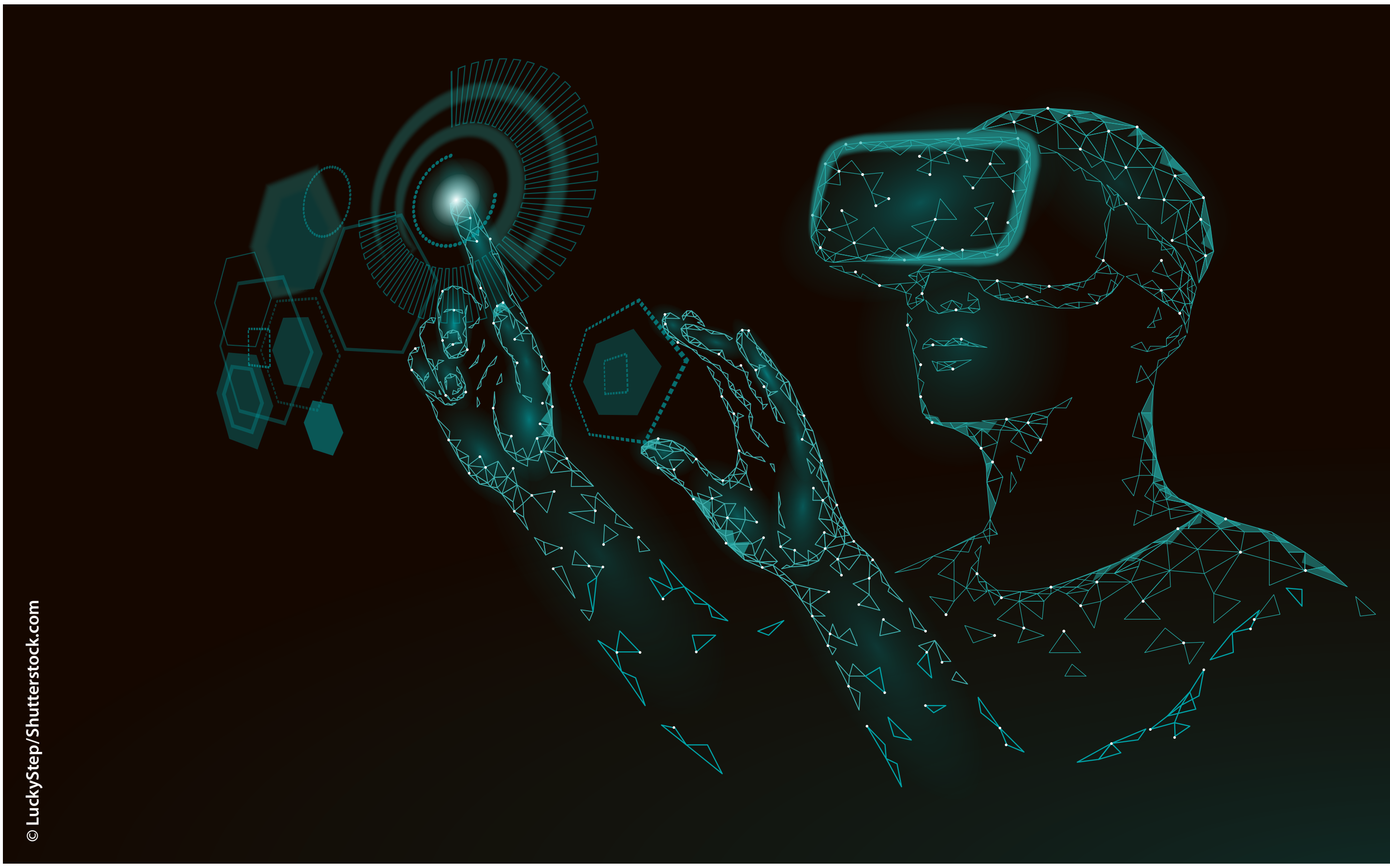
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CHAPTER 4

Training Options and Tactics

4.1 Introduction

Against the backdrop of historical Red Air training approaches and changing threats and challenges, this chapter will survey the range of options available for optimizing Red Air training. Both current and developing tools will be addressed, especially in light of anticipated 6th Generation systems and their training requirements. From the outset it should be stated that the optimal solution for Red Air training will be a combination of the following elements and that there is no single approach – whether live, virtual, synthetic, manned, unmanned, service provided, or contracted – that can cover all the envisioned requirements. The final section of this chapter will identify tactics and training proposals that should be considered as training options are implemented.

4.2 Simulators

High-fidelity simulators are an integral part of 5th Generation fighter acquisition programmes and, from their inception, were designed to augment live training. However, like the aircraft they support, 5th Generation simulators are scarce and expensive, but once fully developed and employed, they produce exceptional value.

Simulators were initially developed to train basic aviation skills, but as their capabilities grew to replicate all aircraft mission systems, the possibility of training to advanced tactics was quickly incorporated. Currently, pilots are able to simulate all mission types, from basic flight to the most advanced training, which incorporates all anticipated threat types (air and surface) in any contested environment. Equally important is the capability to link multiple simulators so that pilots and controllers can practice together against other pilots and controllers operating as an opposing force, all within the same simulation.

Some nations, including the US, are planning for virtual training to be the cornerstone of their next-generation training programmes. Both current and future aircrews will benefit from the ability to practice complex missions – such as Suppression of Enemy Air Defences (SEAD) or Dynamic Targeting (DT) – which otherwise require considerable resources and coordination. EW is especially difficult to conduct in regular training areas, without special permission and training capabilities.[1] Yet all of these things are easy to do, and can be repeated as often as desired, in a simulator.

New technology and connectivity also allows the virtual connection of simulators not only from the same Air Base, but also from different locations, even from different countries and with different types of aircraft. US Air Force assets have been virtually connected since the mid-2000s, but connectivity across services and nations have been slower to field.[2] Adding newer aircraft to the architecture has taken time and, despite successes in experiments and sporadic training events, it is still difficult to widely and persistently connect resources across the nations.[3,4] The first anticipated step in progress is the US Air Force and Royal Air Force fielding of a common Distributed Mission Training architecture to connect US and UK F-35 simulators.[5]

On another front, there are initiatives such as the Multinational Aviation Training Centre (MATC) in the Czech Republic.[6] This NATO-accredited simulation facility provides an advanced resource for allied nations to train complex tactics, techniques, and procedures against a range of threats and environments. The MATC incorporates several operator positions in different resolution versions, allowing virtual collaboration between pilots, each of whom may be piloting replications of different aircraft, with corresponding cockpit display models. While the different nations' building blocks may continue to evolve to meet national training requirements and fielded aircraft, the MATC will continue to provide a virtual context surrounding each mission or role to be trained. In this way, the MATC can dial up the environment's complexity by adding Red threats or Blue air power capabilities, including GCI or tailored operational C2 elements. This centre was funded as a Memorandum of Understanding (MoU) organization between the Czech Republic, Croatia, Hungary, and Slovakia and is used as a pooled resource to conduct tactical simulator training in support of annual training requirements.

Nowadays, it is possible to connect simulators with live missions and interact with the allocated assets in real time, which brings us to the next point, the Live, Virtual, and Constructive (LVC) environment.

4.3 Live, Virtual, and Constructive (LVC)

LVC is a blended network solution linking live and virtual environments to collaboratively train together. In this context, 'Live' stands for a pilot training in his own aircraft; 'Virtual' refers to a pilot training in a flight simulator; and 'Constructive' refers to computer (and/or human) generated entities or effects that support the live or virtual domains. LVC environments can be the economical, adaptive, and personalized solution to regular training.

The simplest LVC option is a live flying aircraft interacting with constructive pre-programmed threats or with threats introduced and/or controlled from a ground station in real time. This option is already fully operational in trainer aircraft such as experienced at the Italian Air Force International Flight Training School (IFTS).[7]

A more complex LVC solution is played in two different ways, with pilots in real aircraft (live) and in simulators (virtual) interacting simultaneously against either simulated (virtual or constructive) or real threats (live air or surface). While this option is promising and already being fielded in operational trainers such as the

IFTS, LVC still poses a number of technical and policy challenges before it can be used to train complex tactical missions with operational 4th and 5th Generation aircraft. For example, bridging national security clauses, protecting against cyberattacks, managing link speed and latency, and interoperability and translation requirements must be addressed.

Assuming those limitations can be addressed, there are still other challenges to solve, including the fact that virtual aircraft, either friendly or enemy, do not create radar signatures without deep integration between the aircraft and radar software. This requires the LVC provider to have full access to the aircraft's and radar's software, something the nations are reluctant to allow. Once the LVC system is fully integrated with the aircraft's and radar's software, virtual and constructive players could be 'detected' by the aircraft's radar and it could also be possible for these virtual entities to simulate the use of expendables such as chaff and flares, inject ground threats anywhere and be able to present as adversary threats.

As stated above, as a conservative working procedure, the option of injecting all kinds of virtual threats into real aircraft is always a consideration, although the same security concerns related to simulator connectivity, such as link security or bandwidth, do apply in this case too. In this way, the CUBIC P-5 Combat Training System[8], which is already included as standard equipment in the F-35, will allow for the future use of virtual air-, land-, or sea-based threats. While the previously mentioned technological and security implications remain unresolved, LVC has the potential to dramatically improve Beyond Visual Range (BVR) training when fully integrated.

Despite the challenges, the benefits of virtual/constructive threats in a live environment are substantial. Since virtual threats and weapons are not constrained by the same limitations as real aircraft, they can 'fly' in any airspace, at distances relevant for long range Air-to-Air (A/A) missiles, and they can 'kill' on impact rather than having to communicate, coordinate kill removal, and regenerate. Furthermore, LVC creates the opportunity to mask certain elements of the real aircraft tactics, crucial for 5th Generation aircraft, although depending on how the real aircraft are being observed some tactics could still be deciphered. Other advantages of LVC include the increased joint interoperability, with the required network in place, and simplified integration of operational domains, which could result in frequent training between NATO forces.

Toward this end, TLP has integrated the so-called 'TLP simulator' system.[9] This system consists of more than 30 fighter cockpits and GCI positions enabling virtual pilots and controllers to carry out training while seated in the same room. It also includes modes related to the 5th Generation aircraft and a huge array of options for modelling platforms, threats, and weapons.

Virtual maritime and land power platforms may also be introduced to enrich the tactical context. Likewise, both the TLP and the participating nations are able to use the simulator to model and execute war gaming of specific missions or scenarios.

This new simulator incorporates connectivity with C2 systems to provide certain degrees of Live-Virtual training and it is already possible to fly virtual Blue and Red tracks, inserted into live-flying scenarios from the simulator's cockpits through the Link-16 network. This very limited first step allows TLP to start integrating LVC technology as Red Air. The first Live-Virtual event (real Blue fighters plus virtual Blue fighters versus virtually generated tracks, both airborne and ground-based) took place in June 2021.

However, the main problem of these LVC systems is that the integration of the virtual threats via Link-16 is very limited and does not generate 'spikes' or radar echoes. Thus non Link-16 capable players will not be able to see them, and the ones with Link-16, will not have them in their sensors, creating a lack of reality for the pilots. This technology is in its early stages as related to operational 4th and 5th Generation fighters and deep and expensive investments are still needed.

Additionally, LVC provides a potential avenue to increase flight safety. While the number of accidents should decrease due to reduced flight operations, this does not imply a reduced ratio of the accidents per flight hour, which could be the same, or even higher if pilot proficiency in live flying declines. Mixing live and virtual aircraft requires consideration to determine the impact on in-flight safety issues. For example, one of the noted benefits of virtual aircraft is the ability for virtual threats to operate outside of authorized training areas to simulate long-range threat aircraft and weapons. As the complexity and realism of LVC training increases – primarily through the incorporation of additional assets, live and virtual – the possibility of inducing the live aircraft to depart the training area increases, especially when a Red Air pilot would have previously had safety responsibilities. In this situation, the virtual aircraft could also induce target fixation by an airborne pilot. Technology can address some of these problems through filters and warnings, or through traditional means via updated training rules, but other unforeseen risks could materialize.

4.4 Augmented Reality (AR)

Another key limitation of LVC is that it only works in the BVR environment. Even with perfect integration among all aircraft and simulator systems in a distributed network, there is currently no fielded capability to simulate visual search and identification outside of the live (with live threats) or virtual environments. AR, where a virtual or constructive threat is projected over a video or live view, could provide this capability.

One US Air Force experiment – involving Red 6 and Lockheed Martin companies – is developing a training capability in which an AI-driven model is displayed through a pilot's visor and manoeuvres like a real aircraft in response to the live pilot's manoeuvres.[10] As a standalone solution, this concept has the advantage of being platform-agnostic and can be easily integrated into any weapons system.[11] It also promises the capability to simulate any adversary aircraft, given the availability of accurate intelligence and aircraft aerodynamic data. If perfected, AR adversaries could theoretically replace live Red Air aircraft, saving pilot hours and significant material costs. Air-to-Air Refuelling (AAR), formation flying, manned/unmanned teaming, and other combat missions requiring visual observation, such as CAS, should also be possible. The first flights with this technology have been successfully performed and further developments are ongoing.[12]

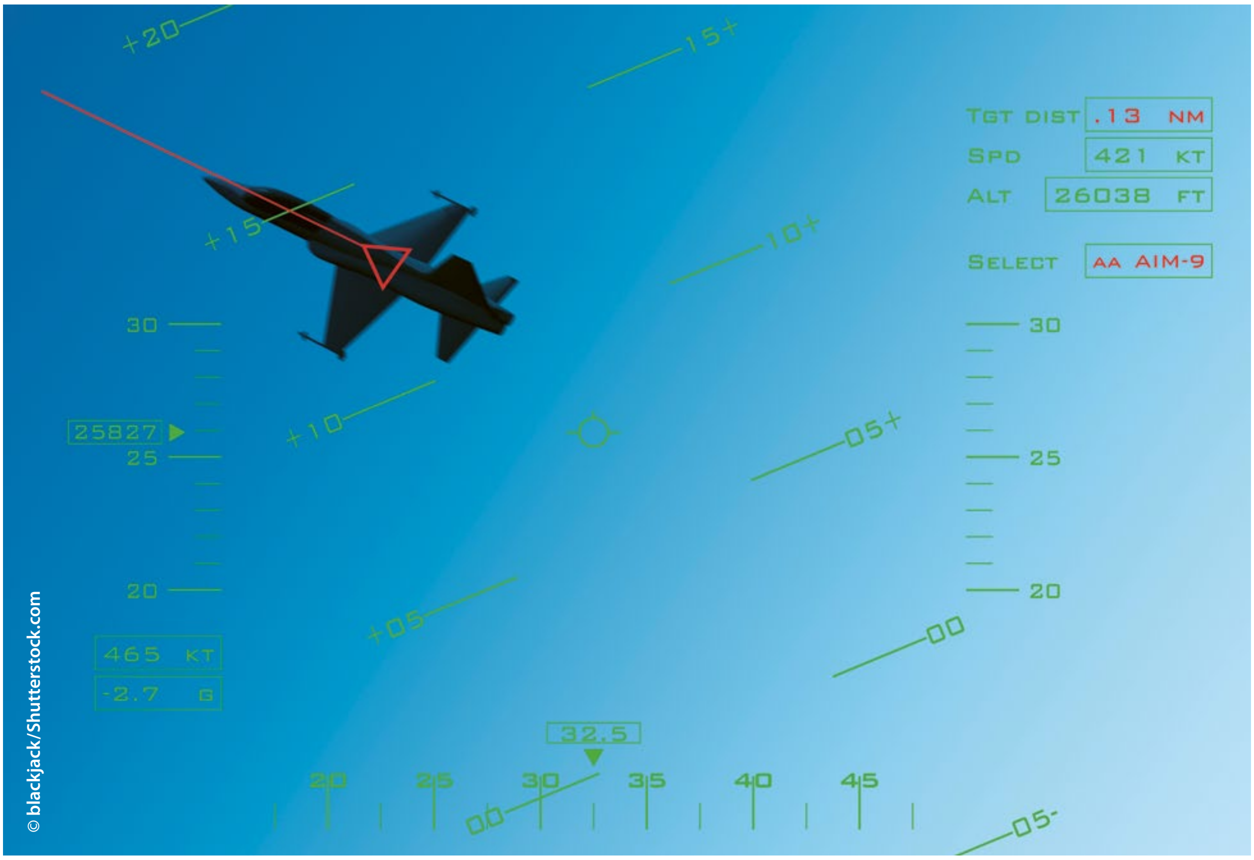
However, as with the LVC systems described before, AR suffers from a lack of sensor integration. While a pilot may 'see' a threat aircraft, the aircraft's sensors and weapons are unable to lock on to it. Until these gaps are closed and LVC and AR capabilities are fully integrated with an aircraft's mission systems, training solutions still need to include live Red Air.

4.5 Live Red Air UAS

As UAS's capabilities improve – and costs decrease – it becomes feasible to consider unmanned Red Air platforms. Without the need for human life support, interfaces, or manoeuvring limitations, UAS should become increasingly cheaper and more effective over time. In fact, by the time this study is presented, it is planned that the first A/A dogfight between a manned aircraft and an AI-driven UAS will have been performed.[13]

However, to consider UAS as a realistic option for Red Air, they must have the same characteristics (or the ability to mimic them) as the platforms they simulate. This will require a significant level of connectivity for control and supervision, a certain degree of autonomy in operation, and will probably require AI, whether on board or networked, to respond as rapidly as the 'Blue Air' human they are training. They should also have the ability for cooperation to execute joint tactics. They should be fast and agile enough to simulate Red Air threat aircraft and should incorporate real emitters to stimulate Blue forces. They should also possess enough endurance, reusability, and affordability to offset the development costs. Given all these requirements, it seems likely that Red Air UAS could also be repurposed for friendly use during conflict.

Apart from the currently fielded ISR UAS and Unmanned Combat Air Vehicles (UCAV), which do not



comply with many of these requirements, there are several highly capable UAS under development in conjunction with 6th Generation projects, including the Future Combat Air System (FCAS)[14], Tempest[15], Next Generation Air Dominance (NGAD), Kratos[16], and the Australian Loyal Wingman Program.[17] Furthermore, the company Exosonic has recently been awarded a contract to develop a Supersonic UAS Concept with Adversary Air Mission Potential by the USAF.[18] While these platforms may meet all or part of the Red Air UAS requirements, the associated costs of these programmes have yet to be seen.

Most of these new A/A capable UCAVs are designed with stealth technologies, which also help to fill the stealth gap in the Red Air arena, which is almost impossible to be filled by manned aircraft at an affordable price. However, stealth UAS and UCAVs will rely on A/A missile manoeuvrability rather than requiring the same degree of manoeuvrability found in a manned fighter. New designs also aim to allow UCAVs to work as a swarm, driven by AI, thus allowing them to develop new tactics and get the best possible solution for every challenge. While these capabilities may potentially be leveraged for use as Red Air trainers, the difference in purpose is not trivial and may result in a design that is suboptimal for repurposing. Additionally, there may be flight safety implications that are acceptable in combat, but unacceptable in training environments (against Blue fighters).

Furthermore, as NATO Air Forces begin to integrate 6th Generation aircraft into their inventory, part of their training requirements will be to fly and interact with unmanned partners. This could generate competition for UAS resources similar to the current shortage of aircraft and pilots, if not programmed and budgeted accordingly. Control and supervision means would also have to be scaled for Blue and Red UAS and the matter of flight safety protocols between manned/unmanned and unmanned/unmanned aircraft would have to be developed.

4.6 Manned Aircraft

Even as simulators develop advantages over live flight, no capability exists yet to replicate the tension and forces experienced during live flight. Only actual flights – whether conducted against LVR, AR, or unmanned adversaries – can prepare pilots for the physical stress of navigating and communicating, while simultaneously executing a combat mission. For this reason, live flight will inevitably continue as an element of training. Also, despite the promise of the technologies discussed before to augment or replace live Red Air in the future, in the near to mid-term, Air Forces will continue to require live adversary aircraft and pilots to effectively replicate the combat environment.

For most NATO nations, the simplest answer remains utilizing local resources (aircraft and pilots) to accomplish Red Air sorties (including those nations with dedicated Aggressor Squadrons). If aircraft and pilot availability was no concern, legacy aircraft could provide adequate complexity for most 5th Generation training and exercises, given sufficient standardization in the aggressor role. However, as we have already asserted, most NATO air forces have become too small to provide their own Red Air without affecting the readiness of aircraft and pilots for primary missions. It has also been noted, that many nations will continue to employ legacy fighters in a cooperative role with 5th Generation assets. Relying on legacy fighters as training aids will affect their ability to train for this new mission. This is especially true when the requirement is to train outnumbered against a credible adversary.

One approach to this situation has been to establish companion training squadrons for US Air Force F-22 squadrons.[19] Similar to Aggressor Squadrons, these units fly AT-38 aircraft as dedicated trainers in local training missions and smaller exercises. This has saved vastly more expensive flight hours, maintenance, and pilot training time for F-22 squadrons. Potential acquisition of an Advanced Tactical Trainer – like the T-7A Red Hawk – to replace the aged AT-38s, could expand the cost benefits and improve the ability of a companion trainer.[20]

Similarly, there has been tremendous growth in private contractors providing Aggressor Red Air services. Starting with old or decommissioned legacy fighters, these companies restored and revitalized 3rd and 4th Generation capabilities through life extension programmes and upgrades like Active Electronically Scanned Array (AESA) radars, Helmet Mounted Cuing Systems, and tactical data links.[21] Impressively, they have managed to field these training forces more quickly than the nations' front line fighters, through non-governmental acquisition processes and simpler security constraints. They have also managed to quickly field experienced pilot cadres by hiring retired or former pilots trained by the nations. While most of the contracts have been for US Air Force and US Navy training, there is increasing evidence of NATO nations exploring and using contracted Red Air.[22,23,24]

Additionally, the US Air Force has identified the requirement for a stealth aggressor capability that can neither be contracted nor replicated with legacy aircraft. This led to the reactivation the 65th Aggressor Squadron (65th AGRS) with 11 early production, non-combat capable F-35As at Nellis Air Force Base.[25] Despite being early block models, the F-35A aggressor provides a unique capability to train, test, and evaluate both high-end and future capabilities and enhance 4th to 5th Generation fighter integration.

While dedicated Aggressor Squadrons, companion squadrons, and contracted Red Air are promising approaches to adversary provision, few (if any) fighter squadrons have the ability to regularly train in massive air spaces, against SAM threats, electronic warfare threats, and with total operational security. Even with high-end dedicated Red Air, Surface-Based Air Defence Aggressors, and the largest ranges possible, there will still be a need for the massive LVC/AR architectures envisioned in the future.

4.7 Tactics

Air-to-Air tactics are currently transitioning from an expectation that discrete flights of aircraft, fielded by individual nations, can accomplish specific mission tasks independently or in coordination with other flights. In the old way, a RNLAF F-16MLU might be responsible for the strike while supported by a GR F-16 C/D conducting SEAD and two US F-22s conducting escort. In the future, F-35s will integrate at the tactical level with strike, SEAD, and escort assets and not merely clear the way for other fighters to execute their mission under an air superiority umbrella. To be clear, the F-35 will be a massive force multiplier; but multiplying the force will require dedicated tactics development and rigorous training to ensure that all the air forces are capable of playing their role.

As those tactics are developed, it is possible to identify a few key elements that will influence Air-to-Air training in the future.

'Live flight will continue to be the only way to prepare pilots for the physical stresses of combat. This will require some combination of live and unmanned Red Air to adequately stress the weapon systems and the pilots.'

First, despite the apparent poor performance of Russian aviation in the early stages of the invasion of Ukraine, NATO forces can no longer train under an assumption of air superiority. Over twenty years in Afghanistan, NATO forces have become accustomed to focusing on CAS operations in a permissive air environment. While there have been tremendous advances in allied coordination, NATO forces must transition to the reality of great power adversaries. Russia and China have fielded advanced Integrated Air Defence Systems (IADS), aircraft, missiles, UCAVs, battle tanks, advanced short/medium/long-range ballistic missiles, and hypersonic weapons. Air superiority will have to be hard won in the future if it can be attained at all. NATO air forces must begin to train for that fight today.

Second, adversaries can play defence even after gaining territory.[26,27] After a rapid feint, occupation of small nations or cross border areas, adversaries have the capability of rapidly converting these areas into defensive havens. Previously, this level of defensive capability would have been reserved to home territories, but now it is materially feasible for adversaries to mobilize and extend their A2/AD bastions on captured territory. Thus, to defend a contested territory requires a significantly higher level of integration simply to provide DCA, C4ISR, or airlift.

Third, adversary A2/AD capabilities will degrade – and at times deny – the C4ISR advantages that NATO nations rely on. With the extension of A2/AD umbrellas capable of detection and engagement out to 200NM against low-manoeuvrable targets, allied AWACS, ISR, and air refuelling aircraft will be required to operate at ranges that will degrade mission coverage and communications. Fighters will also be required to operate in contested electronic environments, with degraded sensors and communications, against an adversary supported by advanced sensors and datalinks. Blue forces must be prepared to operate in contested territories with all of these critical force multipliers degraded or denied.

Fourth, adversaries can mass and create localized numerical superiority over NATO forces. With the proliferation of UAS, adversary forces are now capable of augmenting their frontline fighters with unmanned systems and large numbers of legacy aircraft to surge and outnumber allied forces. Combined with the area denial effect on AWACS and ISR, saturation attacks could significantly degrade fighter SA without much preparation. Given the expectation that a defensively oriented adversary would continue to maintain its own SA and cross-domain integration, friendly forces would be at significantly increased risk of ambush from threat fighters and SAMs. Blue forces must be prepared to fight outnumbered.

Fifth, the threat of advanced A/A missiles cannot be ignored. NATO forces must be ready to employ their own advanced A/A missiles (i.e. AIM-120D and METEOR) against the most challenging adversary weapons, like the R-77 and PL-21. The operational ranges of these weapons present real challenges to national airspaces and require training incorporating both restrictive and non-restrictive Rules of Engagement (ROE).

Sixth, allied forces must train to conduct Multi-Domain Operations (MDO). In the future, technology (i.e. cloud computing, AI, UCAVs, 6th Generation fighters) will enable seamless, rapid coordination of effects across all available domains.[28] While those exquisite capabilities are still under development, currently fielded forces must look for new ways to integrate all of the available capabilities that can bear on their mission. Immediate capabilities that can be incorporated are agile coordination for re-tasking targets in support of higher priority missions; rapid establishment and deconfliction from no fly corridors supporting hypersonic weapons and long-range artillery; and operations supported by manoeuvring GCI and AWACS, and intermittent Joint Force Air Component (JFAC)/Air Operations Centre (AOC) communication requiring reliance on mission command.

'Virtual environments will continue to be the only way to regularly and affordably train against the greatest number of threats without compromising friendly intelligence and tactics.'

In summary:

- Allied forces should train both DCA and OCA missions inside A2/AD threats ranges.
- These missions should be trained with C2 (CRC, AOC, and AWACS), tankers, and basing constrained by A2/AD threats.
- Allied forces should train outnumbered, against an advanced air weapons threat.
- Fighter training should evolve from traditional 2vX and 4vX models to prioritize 5th Generation integration and MDO.

4.8 Conclusion

There are many options available for improving Red Air training in Europe. However, no single solution will be capable of meeting all the training requirements that are essential for preparing NATO forces to counter a peer or near-peer adversary. Instead, the nations should leverage the complimentary advantages of live flight, LVC, AR, and unmanned aircraft to prepare against a more credible adversary.

Live flight will continue to be the only way to prepare pilots for the physical stresses of combat. This will require some combination of live and unmanned Red Air to adequately stress the weapon systems and the pilots. In the future, LVC and AR capabilities should be integrated seamlessly with aircraft systems to project a greater number of air and surface challenges for the pilot's training.

Virtual environments will continue to be the only way to regularly and affordably train against the greatest number of threats without compromising friendly intelligence and tactics. In combination with complex live flight training, LVC and AR can provide a larger and more complex battle space without many of the real world constraints (e.g., air space limitations and EM restrictions) that hamper live training. As LVC integration and realism increases within fighter cockpits, the cost benefit of LVC should increase as well.

The nations must also rapidly pivot to realistic training against advanced threat systems, A2/AD environments, and degraded C4ISR and electromagnetic operations. At the same time, the nations will need to anticipate and account for the flight safety challenges that will accompany increased flight operations, and UAS in close proximity to Europe's congested air routes. Finally, the nations should also anticipate the fielding of future fighter and C2 systems and their incorporation in the training architecture.

All that remains is how to address these options within NATO.

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CHAPTER 5

Conclusion and Proposals

5.1 Introduction

NATO nations face two interrelated Red Air challenges. One is organizational, the other is material.

Organizationally, there is a knowledge gap within the individual nations and the Alliance collectively about how Red Air should be conducted. Few nations currently have the capability to develop and present credible Red Air forces and there is no NATO capability outside of voluntary national contributions, which generally occur at an unclassified level. Credible Red Air presentation requires intelligence, standardization, and training/certification of specialized aggressors or rigorously managed unit-level programmes. Any future Red Air approaches must address the knowledge gap and not simply focus on hardware or contracts.

Materially, as asserted before, there is simply not enough Red Air capacity within the nations to adequately train against an advanced threat. Even nations with the most developed Red Air organizational capability lack capacity to present realistic threat forces. Without augmentation, such as dedicated Aggressors, companion trainers, or contract adversaries, vital Red Air sorties will still come at the expense of other Blue fighter readiness. Moreover, where LVC capabilities are greatest, they are still a generation away from being able to integrate all of the sensors needed to reduce or eliminate a live/unmanned Red Air requirement. Technology is simply not ready to replace Red Air aircraft and pilots and the Air Forces are too small to continue providing

Red Air 'the old way.' This paper offers three proposals to address these challenges. The first two, the creation of national and NATO Red Air Standards Branches, address the knowledge Gap. The third, creating a multinational Aggressor Unit within NATO, addresses both the materiel and knowledge gaps.

5.2 Proposal No. 1: A National Red Air Standards Branch

The most basic component of the Red Air enterprise is the ability to standardize friendly understanding of adversaries' mission performance. Presently, or in the future, no matter what approach a nation takes to Red Air, creating adversary standardization will improve the conduct of training at the unit level by a) eliminating variation in favour of best practices and b) reducing workload for pilots and instructors. Ideally, a Red Air Standards Branch would closely coordinate with – or include – intelligence professionals to ensure that training reflects the nation's best understanding of adversary capabilities and tactics.

Where a nation is able to field or contract a Red Air squadron, the Red Air Standards Branch would provide guidance and oversight. It could also be a function of that Aggressor Squadron itself to fulfill the Standards Branch's role for local units. Additionally, the branch would be responsible for representing Red Air equities for training issues involving technology, ranges, and aircraft utilization, especially with LVC/AR, UAS, and UCAV in the Red Air role.

The branch would also be responsible for coordinating Red Air forces during national and regional exercises. As Red Air experts, the branch could be charged with developing the Red Air concept, coordinating resources among participants (national and external), and acting as the Red Air Coordination Cell during the exercise.

Finally, given the availability of highly experienced aviators in European air forces, it should be possible to staff a national Red Air Standardization Branch with retired or non-flying pilots. Alternately, if mid-career pilots were responsible for the branch, it could potentially be tasked with an operational role demonstrating and training Red Air tactics in the nation's squadrons.

5.3 Proposal No. 2: An International Red Air Standards Branch

On a larger scale, the allied nations would benefit from the same standardization across all of their air forces. Whether as a NATO undertaking, a purpose-built consortium, or under the guise of an existing MOU entity, an International Red Air Standards Branch would capitalize on the intelligence and resources of the contributing members and disseminate a coherent approach to replication of Red Air weapons and tactics. Ideally, when the branch is chartered, the participants should agree to disseminate NATO classified standards for the benefit of all NATO air forces.

An International Red Air Standards Branch would also be the focal point for adversary training capability development in NATO. The branch would represent Red Air expertise to the technology development community and within the Education Training Exercise and Evaluation (ETEE) enterprise. It would be the primary source to develop Red Air plans for major NATO exercises and lead the Red Air Coordination Cell during execution.

The International Red Air Standards Branch would be responsible for developing relationships with national branches, Aggressor Squadrons, Companion Trainers, and Contract Red Air to coordinate training within NATO.

Finally, NATO should consider leveraging the flying training mission at TLP to conduct a NATO Red Air Standardization Course. TLP already depends on participating nations to provide Red Air. However, with an enlarged focus, these forces could be the seed corn the nations need to professionalize their own Red Air capability. Red Air students could follow the same general course structure as TLP and progress from academics to simulation to live flying. It should be understood that any increase in the TLP mission would require additional resourcing and funding, but a Red Air Course could leverage expertise from the International Red Air Standards Branch. Finally, if it becomes NATO-accredited, the Red Air Course could become a requisite for assignment to national or international Red Air Standardization Branches.

5.4 Proposal No. 3: A Multinational Aggressor Unit in NATO

NATO, and the nations, have a long history of pooling resources to fund the critical capabilities that would otherwise be out of reach. These include the NATO Airborne Early Warning (NAEW), the Multinational Multirole Tanker and Transport Fleet (MMF), the C-17 Strategic Airlift Capability/Heavy Airlift Wing (SAC/HAW) and the Tri-National Tornado Training Establishment (TTTE). Given the commonality of the problem, it is time to consider the creation of a multinational Aggressor Unit.

'Simply put, there are not enough aircraft and pilots to properly train NATO air forces effectively, if the nations continue to rely on traditional models for Red Air.'

Credible Red Air training is already beyond the reach of individual units and (perhaps) nations to accomplish without pooling. Optimum training for NATO Air Forces with the integration of 5th and 6th Generation aircraft will only be achieved with the participation of very robust, structured, opposing forces composed of Red Air, SAM, and EW capabilities. Creating a unit of NATO Aggressors would be the most effective way to create a trained and credible cadre of Red Air experts to participate in major exercises, develop standards for unit level training, and acquire the expertise to inform LVC, AR, UAS, UCAV technology development efforts.

This Aggressor Unit, as a multinational entity, could be created via several different approaches. It could be created within the NATO Command Structure (NCS) with NATO-owned assets. In this way, it could be composed of retired and upgraded 4th Generation fighters or with new purchased tactical trainers, such as the T-7A. Alternately, it could be established as an MOU organization associated with NATO, but outside of the NCS, in the manner of SAC/HAW. An MOU organization modelled after SAC/HAW could operate with collectively acquired assets or with national resources under transfer of authority (TOA) to the organization. Finally, it could be built as an MOU organization established to administer a contract for Red Air with private entities. The MOU organization could fill the International Red Air Standardization role and supervise execution of the contract without owning any aircraft or pilots.

In either of the first two models, an International Aggressor Unit could be located at a specific home base and deployed for exercises and local training road shows. Alternately, it could be located at a few regional bases as detachments and reconvene as one large unit for major exercises. The choice of basing should be informed by the number of pilots available, aircraft availability (i.e. new aircraft would be easier to disperse than maintenance intensive, repurposed older fighters would), and the agreed-upon mission for the unit. If the priority was on day-to-day local unit training, then a dispersed model might make most sense, but at the risk of spreading the resources too thin to adequately train for the high-end fight. If the priority is on major exercises, supporting TLP, and larger regional training events, then a more centralized approach would be preferred. In either case, the priority should be on creating a unit with sufficient resources to create Red Air expertise and consistently provide high-end training to NATO forces. Any excess capacity could be offered to the nations through HERMES.

The TLP, with its assigned infrastructure and airspace, with the introduction of the initial LVC capability, and with all types of opposing assets, including Red Air, SAM and EW, can be considered as an option to locate a NATO-owned Aggressor Squadron. The synergy between advanced training and advanced adversary replication would be beneficial in the same way the US centre for Red Air operations is collocated at Nellis

AFB alongside the US Air Force Weapons School. MOU-driven Aggressor Units would be constrained by member nations and the airfields available to them.

An NCS or MOU-based unit would require assigned pilots, intelligence officers, controllers, and supporting elements for flight operations and maintenance. The nations would be expected to provide highly experienced, mid-career officers for a 3–4 year assignment specializing in Red Air weapons and tactics. In return, the unit would be responsible for efficiently training these officers to be Red Air experts. This capability would then feed right back into the nations upon completion of the tour.

Additionally, an International Aggressor Unit would be in charge of developing, updating, and disseminating the Red Air standards assigned to the International Branch described before. These could be disseminated via the standard NATO channels and augmented with academic 'Road Shows' during exercises or regional training events. The unit would also be responsible for training the nations to conduct Red Air replication instead of, or in addition to, TLP (as described before). Furthermore, the unit would be responsible for supporting Alliance tactics development experiments, whether live, virtual, or conceptual. Finally, the unit would be responsible for Red Air Coordination Cell for any exercises it supports.

Depending on its manning construct, the International Aggressor Unit could assume all of the responsibilities of the International Red Air Standards Branch or just those directly related to flying operations. Whether alone or in coordination with an International Red Air Standards Branch, the unit would need to coordinate closely with NATO ETEE processes to ensure that its training road map is synchronized with NATO exercises and experiments.

With respect to private contractors, any of the proposed configurations could be responsible for hiring and supervising commercial Red Air. As was noted earlier, the largest consumer of contract Red Air utilizes their services in conjunction with dedicated Aggressor Squadrons, which provide the employment standards for adversary operations. NATO would also require the ability to standardize Red Air execution. Still, any of the models for an International Standards Branch or International Red Air Unit could accomplish

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this so that contracted Red Air could fly (or augment NATO Aggressors) during exercises, TLP, regional training events, or unit level training. Any proposed international entities could serve as a vehicle to offer Red Air forces to the nations via HERMES.

Finally, as the Alliance is built around specialization and the division of labour, any nations that develop Red Air or other Aggressor capabilities outside of the international branch or unit could still collaborate with any collective entities. It is not expected that the US, for example, would shutter its Aggressor operations because of the international unit. However, the International unit would be a focal point for coordinating all national contributions to NATO exercises, training, and experiments.

5.5 Conclusions and Recommendations

With the transition to smaller fleets of more capable 5th Generation fighter aircraft, NATO nations face the challenge of maintaining fighter proficiency while simultaneously supplying credible Red Air training sorties. If the nations continue to rely on traditional models for Red Air, there are not enough aircraft and pilots to properly train NATO air forces to desired standards. This problem will only worsen with the introduction of the 6th Generation aircraft.

A broad range of options exists to provide future Red Air capabilities, some of which have the potential – in the long term – to reduce the flying requirement for live Red Air aircraft and pilots. These include simulators, LVC environments, AR, UAS, and different delivery models for aggressor forces, including contracted Red Air.

However, none of these options – with the exception of contracted Red Air or Red UAS – have the potential of replacing the benefits of in-flight training against a live adversary aircraft. At the same time, there are downsides to live flight training that can only be mitigated through the development of capable alternative training environments and methodologies. There are a few ranges large enough to conduct unrestricted training against the expected numbers of threat aircraft, missiles, and electromagnetic operations at appropriate distances to train the entire scope of required missions. Finally, while there are promising technological advances like AR, AI, and machine learning that could someday bring the benefits of virtual environments into live aircraft, they involve significant technical and policy risks that make it unlikely for a combined LVC environment to completely replace live or unmanned Red Air.

JAPCC recommends that the nations establish a Multinational Aggressor Unit to provide NATO with an Air capability to support major exercises, experimentation and even the TLP. Additionally, such a unit could provide the basis for standardization among the nations, increase the quality of training, and reduce the overhead of running a unit-level program. It could also serve as a clearinghouse to integrate and contract private Red Air on behalf of the Alliance or the nations. In this way, a Multinational Aggressor unit could solve both the knowledge and materiel gaps faced by the nations.

ANNEX A

Acronyms and Abbreviations

AAR	Air-to-Air Refuelling
AESA	Active Electronically Scanned Array
AGRS	Aggressors Squadron
AI	Artificial Intelligence
AOC	Air Operations Centre
AR	Augmented Reality
ATARES	Air Transport & Air-to-Air Refuelling and other Exchanges of Services
A/A	Air to Air
A2/AD	Anti-Access/Area Denial
BVR	Beyond Visual Range
CAIP	Combined Air Interoperability Programme
CAS	Close Air Support
COVID	Coronavirus Disease
CRC	Control and Reporting Centre
C2	Command and Control
C4ISR	Command and Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance
DAS	Distributed Aperture System
DCA	Defensive Counter Air
DT	Dynamic Targeting
EAG	European Air Group
EDA	European Defence Agency
EME	Electro-Magnetic Environment
ETEE	Education Training Exercise and Evaluation
EW	Electromagnetic Warfare
FCAS	Future Combat Air System
FFAO	Framework for Future Alliance Operations
GCI	Ground Controlled Intercept
HERMES	Harmonized European Red-Air Means Exchange System
IADS	Integrated Air Defence System
IFTS	International Flight Training School
ISR	Intelligence, Surveillance, and Reconnaissance
JFAC	Joint Force Air Component
LVC	Live Virtual Constructive
MATC	Multinational Aviation Training Centre
MDO	Multi-Domain Operations
MLU	Mid-Life Update

MMF	Multinational Multirole Tanker and Transport Fleet
MOU	Memorandum of Understanding
NAEW	NATO Airborne Early Warning
NATO	North Atlantic Treaty Organization
NCS	NATO Command Structure
NGAD	Next Generation Air Dominance
OCA	Offensive Counter Air
ROE	Rules of Engagement
SA	Situational Awareness
SAC/HAW	C17 Strategic Airlift Capability/ Heavy Airlift Wing
SAM	Surface to Air Missile
SEAD	Suppression of Enemy Air Defences
SIGINT	Signals Intelligence
SOP	Standing Operating Procedures
SPINS	Special Instructions
TA	Technical Agreement
TLP	Tactical Leadership Programme
TOA	Transfer of Authority
TTTE	Tri-National Tornado Training Establishment
UAS	Unmanned Aircraft System
UCAV	Unmanned Combat Air Vehicle

ANNEX B

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ANNEX C

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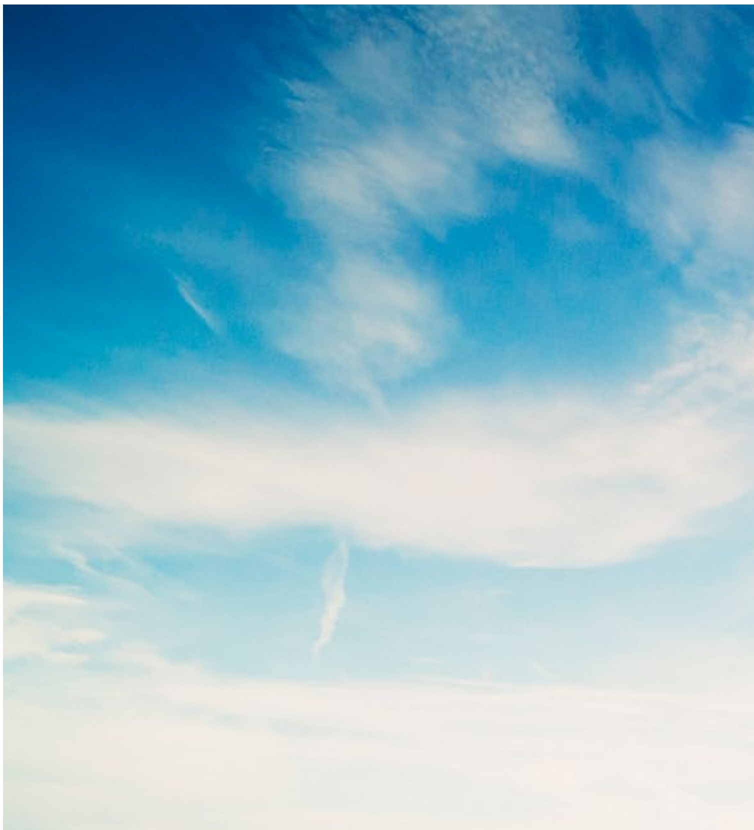
Notes

Notes



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