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Reshaping Close Support

Transitioning from Close Air Support to Close Joint Support

Joint Air Power Competence Centre

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FROM:
The Executive Director of the Joint Air Power Competence Centre (JAPCC)

SUBJECT:
Reshaping Close Support – Transitioning from Close Air Support to Close Joint Support

DISTRIBUTION:
All NATO Commands, Nations, Ministries of Defence, and Relevant Organizations

The aim of this report is to show how 'close support' mission operations in the future may be drastically different than what the Alliance has conducted over the last 30 years. It addresses potential shortfalls in available assets resulting in close support coverage limitations. It also portrays the potential challenges of providing close support to troops in areas that are highly contested.

The report references emerging and future joint military technologies and weapon systems to help solve both coverage gap and contested environment challenges. It concludes with considerations for Alliance transformation at the strategic, operational, and tactical levels.

As you will see, this study stresses the real need for cross-service and multinational interoperability, and shows how a true joint solution is the only plausible path for the Alliance to succeed in achieving the critical close support requirements of the future.

I invite you and your staff to read through this study. We welcome any comments you may have with regard to this document or future issues it identifies. Please feel free to contact the JAPCC's Combat Air Branch via e-mail: combatair@japcc.org.

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PRELUDE

A Future Vision of Close Joint Support

Troops are in contact across a broad, disjointed front. Joint Fires Controllers (JFCs) and their assigned teams of Joint Fires Observers (JFOs) are in high demand and are faced with a daunting environment. They operate under overlapping layers of modern enemy air defences, with contested communications and against an enemy that is adept at movement and concealment. Thankfully, JFCs and JFOs have trained 'cross-domain' for years, effectively utilizing linked simulators and large Close Joint Support exercises to train throughout the spectrum of these environments. They are equipped with the latest digital radio equipment, including gateways for multiple message formats, and mobile communication terminals. They are also prepared for 'old school' voice-only communications with minimal digital aids. They are ready.

A mixed flight of a Forward Air Controller (Airborne) (FAC(A)) F-35, multi-role F-16s (SEAD and attack), F/A-18Es (SEAD and attack), and embedded EA-18Gs (EW) terrain mask away from the fight. The F-35s climb just enough to ensure digital communications are established with the Joint Fires Support Coordinator (JFSC) of the supported brigade combat team so the aircrew can build situational awareness of the battlefield and report the aircraft status to the Multi-Domain Command and Control System (MDC2S). The F-35s, in turn, relay the battlefield picture to the F-16s, F-18s, and EA-18s through various data protocols.

With hardly a spoken word, the JFC calls for fire through digital means. The MDC2S has data about all connected weapon systems across all domains and processes the request in real-time. While considering time-on-target and weapon effect radii, the MDC2S presents a computer prioritized list of available attack options together with the respective Collateral Damage Estimate (CDE) to the JFSC. The JFSC confirms the MDC2S proposal of assigning the F-35's mixed flight to the fire mission. All 'players' acknowledge the data and follow the F-35's lead as he/she 'quarterbacks' the attack and coordinates each asset's roles.

On cue, the team executes a coordinated attack on a motorized, enemy fire team. The aircraft attack under a protective bubble provided by the F-35, EA-18s and UAS. These aircraft jam enemy radars and enemy communications and sweep the skies for enemy aircraft. The F-16s and F-18s use their multi-role capabilities to release network-enabled weapons, which are subsequently guided by the JFC to the target, while simultaneously searching for radar threats to target with their hypersonic ARMs (anti-radiation missiles). The aircraft are in and out of the most lethal threat envelopes in minutes and one of the JFC's JFOs confirms the enemy fire team has been neutralized.

However, the fight rages across a long and disparate front, and there aren't enough airborne assets to service every validated fire support request. Consequently, a distant JFC finds itself in heavy contact against mounted enemy with heavy direct fires capabilities and are in danger of being overrun. The digital urgent troops-in-contact message goes out on the MDC2S, requesting to interdict and destroy the advancing enemy. The troops-in-contact message is now prioritized by the MDC2S and the system proposes to assign two MLRS rocket launchers to deliver a short duration scatterable minefield and three artillery platoons to destroy the enemy vehicles once they hit the mine barrier. The JFSC coordinates with the CAOC through a 'dynamic airspace synchronization' application and ensures that the artillery is cleared to fire through CAOC controlled airspace. Tactical UASs, all tied into the multi-domain net, position to assist with adjusting fires. Within minutes from first contact, the scatterable minefield stops the advancing enemy and forces him to dismount his infantry. The artillery gun's target coordinates are updated in real-time by the supporting UAS and the JFOs on the scene, adjusting the fires into the massing infantry, effectively ending the dismounted attack. However, the fight is not over.

An enemy tracked, large calibre weapon system arrives on the scene and begins to fire, with devastating effects. Despite having crew-served weapons, friendly troops are in danger of being torn apart. The JFC updates the TIC request to reflect the presence of a large weapons system and the effect it's having on friendly troops. Help comes far away, but arrives quite quickly.

One of the Navy's new 'Large Surface Combatant' (LSC) ships, equipped with the newest hypervelocity weapon system, is near-by and automatically populated within the MDC2S. The list of available weapons is sent to the JFSC and from having ample experience training with naval gunfire support, the JFCS quickly selects the projectile. Dynamic, real-time coordination occurs with the CAOC and the Navy's Maritime Operations Center (MOC) to deconflict airspace and coordinate the close support fires. The JFC provides precision coordinates and the LSC fires on command. The projectile covers the distance in seconds. Though the ordnance is not explosive, the kinetic impact of the hypersonic rounds hitting the enemy weapons system is devastating and destroys it in-place. Having seen their firepower demolished and their troops razed by mortar fire, the enemy withdraws.

CHAPTER 1

Introduction

Over the past two decades, NATO air operations took place in a predominantly permissive air environment and Allied Air Forces were able to conduct Close Air Support essentially unchallenged. Enjoying virtually complete air superiority, Allied Unmanned Aircraft Systems (UAS) vastly amplified the availability of air assets at any given time. Better and better sensors, as well as the possibility to stream Full Motion Video (FMV) to the troops on the ground, brought significant enhancements to both positive target identification and the targeting process as a whole. Additionally, more accurate Precision-Guided Weapons (PGMs), many with smaller payloads, led to greatly reduced collateral damage. Subsequently, an entire generation of CAS participants 'matured' in this asymmetric environment, spawning CAS Tactics, Techniques, and Procedures (TTPs) that were created to continue in this environment indefinitely.

However, within the last few years, the world's geopolitical environment has drastically changed. For example, the 2014 illegal annexation of the Crimea peninsula renewed and escalated tensions between the Alliance and Russia. Five years on, tensions have only increased. Half a world away, a militarily aggressive China has claimed increasing swaths of contested territory in the South China Sea, threatening their neighbours and causing consternation on the international scene. These great power schisms threaten the continuation of peace and have made it necessary for the Alliance to re-evaluate potential future conflict scenarios. As a result, the NATO Wales (2014) and Warsaw (2016) Summits, therefore, highlighted

the need to re-orient NATO and its capabilities to (again) deal with a potential peer-to-peer competitor. The latest Summit in Brussels (2018) again renewed emphasis on deterrence and collective defence.

Unfortunately, while NATO was busy fighting an asymmetric war on terrorism, Russia and China continued to improve their conventional military capabilities, both technologically and in terms of the sheer number of systems. The results of their efforts are striking. They have the capabilities in place today to essentially deny huge swaths of airspace, large amounts of which are national airspace of NATO nations. In fact, even without the presence of enemy fighters, layers of adversary long and short-range Air and Coastal Defences, along with very capable electromagnetic (EM) systems, could establish areas which cannot be accessed by NATO aircraft without significant effort and attrition.

Over the last several decades air assets have been available (for CAS) nearly 24 hours a day; however, decreasing inventories of friendly aircraft and competition for Allied air assets in a conventional, large force conflict could drastically change the close support paradigm. Restated, if the Alliance is forced to fight a peer adversary, the relative numbers of aircraft will likely be fewer and the types of missions they are supporting will increase as the air component will again prosecute missions such as strategic strike and interdiction of enemy forces in rear areas. The final result is that CAS resources may be scarcer than the Alliance has seen since prior to the Vietnam War.

Consequently, Close Air Support needs to adapt for potential war scenarios by incorporating, and realistically evaluating, new technologies, assets, competitors, and environments.

1.1 Aim

This study aims to provide recommendations on how Close Air Support should adapt to the meet the challenges of a drastically changed geopolitical environment, considering current and emerging technologies as well as potential future adversaries and operational environments. It further aims to provide recommendations on how to leverage other types of fire support, from all domains, to complement, enhance, or even substitute Close Air Support in situations where airspace access is denied or aircraft availability is significantly limited. Finally, this study aims to provide a vision of a broad concept of 'Close Joint Support', i.e. support that will be conducted across all domains, supplied by actions taken from all services and participating nations. This vision should be considered as a starting point for future joint fire support concepts and doctrine.

1.2 Methodology

In order to determine how the Alliance's current close support procedures have been influenced and developed, in Part I the authors have conducted a brief review of the history of Close Air Support. Because there are still likely future conflicts that will occur against an inferior-sized and technologically deficient adversary, some existing concepts of CAS surely remain valid in future scenarios. On the other hand, symmetric warfare against another military superpower is also not new, and lessons from the past may help to solve similar problems in the future. In order to streamline the reading process for those with a strong historical background, the historical summary of close support has been placed in Annex A. Drawing from the history given in Annex A, the historical lessons learned which deem relevant for current and future close support missions are stated. Deriving from these historical lessons, the study describes the key elements of close support and how they function as a pre-requisite for accomplishing the close support mission.

Part I continues by identifying the elements of potential future conflict scenarios which oppose the key elements, directly challenging the ability to conduct close support. Deriving from this comparison of key elements and their opposing counterparts, Part I of the study concludes with a discussion about the challenges of conducting close support in the future and especially considers the difficulties that may be presented if up against a peer adversary.

Part II of the study describes a multitude of delivery platforms that have the potential to achieve effects in a close support situation. The section begins with the most common type of platform supplying traditional CAS (Manned, Fixed-Wing) and concludes with many other current and future possibilities of platforms from which to draw effectors. This section describes each platform and discusses the capabilities and limitations, including drawing predictions about future technology advancements and how they may or may not enable the platform to support effective close support operations.

Part III of the study provides details and recommendations on how NATO should evolve in order to meet future close support requirements through the utilization of Close Joint Support.

1.3 Limitations

Research and analysis associated with this study include both open and classified sources. To permit the widest dissemination, the published study has been kept at the unclassified level. If classified sources were used, only unclassified information was extracted.

Part I

Close Air Support

CHAPTER 2

Principles of Close (Air) Support

The terminology included in this report is provided to give the reader clarification for CAS terms that may differ between nations or are not defined. Since this paper is written for a 'joint' and civilian audience, these definitions are provided to build a baseline of knowledge in order to more easily discuss CAS doctrine and concepts for a reader who doesn't have detailed background on the subject. Finally, all definitions given below, unless otherwise annotated, are provided in the context of 'for the purpose of this study only'.

In the United States Air Force's CAS Doctrine[1], which has been adopted by NATO, CAS is defined as an 'air action against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with fire and movement of those forces' for fratricide avoidance and terminal attack control performed by a certified and qualified Joint Terminal Attack Controller (JTAC).

This definition holds many terms which requires further explanation and are described below in order of their appearance.

2.1 Close Proximity

Close proximity does not represent a specific distance. Instead, the word 'close' is situational and requires detailed integration and terminal attack control (TAC) based on friendly force proximity to enemy targets[2]. Detailed integration and TAC help ensure engagement of correct targets and mitigation of friendly fire incidents and collateral damage. Thus, CAS is not defined by a specific region of an operation, but is required when friendly surface forces are in close proximity to enemy targets.

2.2 Detailed Integration

Similarly, the requirement for 'detailed integration' because of fires, proximity, or movement is the determining factor for CAS[3]. Detailed integration describes a level of coordination required to achieve desired effects while minimizing the risk of a friendly fire incident – from either surface fires or air-delivered weapons. Because of this level of integration, each element should be controlled in real-time to prevent friendly fire incidents with ground or air forces. Procedures should be flexible enough so that CAS, surface fires, and the ground scheme of manoeuvre are not overly restricted.

2.3 Terminal Attack Control

TAC is the authority to control the manoeuvre of and grant weapons release clearance to attacking aircraft. TAC must not be confused with terminal guidance, which is different and only comprises those actions that provide approaching aircraft information regarding a specific target location without the authority of TAC.

2.4 Joint Terminal Attack Controller

A Joint Terminal Attack Controller (JTAC), Forward Air Controller (FAC), and Forward Air Controller (Airborne) (FAC(A)) are qualified (certified) service members who, from a forward position, directs the action of combat aircraft engaged in close air support and other offensive air operations[4]. Only a JTAC, FAC, or FAC(A) is certified and qualified to conduct TAC.

1. United States Air Force (USAF), 'Doctrine Annex 3-03 – Counter land Operations', in Lemay Centre for Doctrine, 2019. Available online at: https://www.doctrine.af.mil/Portals/61/documents/Annex_3-03/3-03-D15-LAND-CAS.pdf, accessed Jan. 2019.
2. Ibid.
3. Ibid.
4. Traditionally a Forward Air Control (FAC) and Forward Air Control (Airborne) are qualified to provide TAC and are also qualified combat aviators. Both are part of the TACP, with the FAC being ground-based and the FAC(A) being airborne.

CHAPTER 3

Historic Lessons from Close Air Support

3.1 Historical Lessons Identified

Several lessons can be drawn from the historical development of CAS, as described in Annex A. Many of these lessons contributed to the increasing success of CAS over the last 100 years, however, some conclusions can also be drawn which point to future concerns.

3.1.1 Integration

The continued improvement of integrating air assets with ground forces has been shown to be key to the successful conduct of CAS. This has been achieved through modern robust communication systems, coordination of efforts, and international joint training.

3.1.2 Accuracy

The more precise the airborne weaponry that was employed, the more effective the CAS operations were. Guided weapons and precision navigation systems have enabled CAS to be conducted in closer proximity of friendly forces and were a significant factor in being more effective while also resulting in less collateral damage and fratricide.

3.1.3 Control of the Air

An ever-greater degree of control of the air domain has been achieved, which in turn has led to a significantly higher number of CAS sorties available to the ground forces. However, this achievement was mainly due to the changing nature of conflict, being mostly asymmetric in recent decades. Recently, aircraft developments and TTPs have been developed with a permissive environment in mind. However, future conflicts against a peer opponent will likely require experience and knowledge of higher-threat TTPs which have not been trained to for decades.

3.1.4 Ground Forces Dependency on Close Support

In almost every conflict since the Vietnam War, ground forces enjoyed the convenience of air support practically 24 hours a day. Due to CAS being overwhelmingly effective as a result of the three historical lessons just stated, ground forces have become over-reliant on the use of CAS instead of providing ground support through organic means. This had been witnessed by the JAPCC while taking part in a multitude of NATO exercise series where either complete air dominance was anticipated as a constant condition or inconvenient opposing force A2/AD capabilities were trivialized and considered defeated and therefore excluded from the operational planning process right from the start.

In the few scenarios when friendly CAS assets were kept from providing close support due to opposing force anti-air capabilities, friendly ground forces did not have adequate resources to provide organic support and suffered substantial losses.

3.2 Key Elements of Close (Air) Support

CAS is defined as 'an air action against hostile targets which are in close proximity to friendly forces and which require detailed integration of each air mission with the fire and movement of those forces.' Employing ordnance within close proximity of ground troops and the requirement for detailed integration are two characteristics that distinguish close support from other types of air warfare.

Deriving from that definition and taking the historical lessons from Annex A into account, two key elements of close support can be identified, i.e. 'Integration' and 'Accuracy'. Additionally, although not part of the definition itself, but also clearly deriving from the historical lessons, 'Control of the Air' is another key element. Lastly, in order for close support to be effective it requires a certain amount of timeliness (from the time the support is needed until the effect is achieved), especially when considering close support given while friendly troops are in contact with the enemy.

Considering the current state of Alliance CAS capability, if these key elements are not able to be maintained, close support effects will likely be severely degraded or inhibited. Each of these elements will be described, next, in more detail.

3.2.1 Integration

The requirement for detailed integration because of fires, proximity, or movement is the base on which close support is founded. Detailed integration describes a level of coordination required to achieve the desired effects on the enemy force while taking into consideration the possible collateral effects on friendly and neutral personnel and assets. The level of integration required for a specific close support event can be determined by the ground commander or delegated to the JTAC orchestrating the mission, based on the ground commanders' intent and the rules of engagement. The amount of integration that is required varies depending on the proximity of the fires to friendly forces and assets, along with civilian population and infrastructure. Other factors such as the urgency for the desired effect to be achieved, and the destructive potential of the weapon chosen, can play a large role. Highly detailed integration reduces the risk of an undesired effect, but often comes at the cost of increased time to provide the effect. In a time-critical situation, such as friendly troops receiving effective fire with no avenue for retreat, an increase in risk of undesired effects may be acceptable in order to reduce the risk of friendly casualties from enemy fire more quickly. Consequently, detailed integration and coordination of close support, surface fires, and the ground scheme of manoeuvre requires robust and reliable means of communication, protected from attacks through cyberspace, between all friendly forces in the Joint Operations Area (JOA). The JTAC is required to maintain this reliable communication between the supported troops while concurrently keeping the same reliable communication with the asset(s) providing the CAS. If either link is broken, the close support will immediately be suspended until communications are re-established. Detailed integration is only possible if all personnel use common lexicon, compatible communications systems, and are proficient in the use of standardized procedures, executing the same TTPs.

3.2.2 Accuracy

Due to the close proximity of friendly or neutral assets to a target, the level of weapons accuracy is of paramount significance. It is also important to understand that each weapon considered to be used to create a kinetic effect has an established accuracy based on the characteristics of the weapon and platform employing the weapon. The scenario and proximity of the target to friendlies and civilians may prevent many weapons from being used not solely based on their established blast pattern, but also based on their Circular Error Probable (CEP)[1]. As weapons accuracy has improved with precision-guided munitions, especially in a permissive environment with reliable positioning information such as GPS and/or laser guidance available, the same size warhead can be used for close support in more situations giving the JTAC many more options to create the ground commanders' desired effect.

When considering positioning-denied environments or scenarios where laser guidance isn't feasible, many platforms, such as attack helicopters and jet aircraft have unguided ordnance options such as rockets or bullets from their gun to provide precise fires. Therefore, it's important to note that while PGMs have dramatically increased the effectiveness of CAS in recent conflicts, unguided munitions may continue to have an important part in the future of close support, especially in contested environments.

3.2.3 Control of the Air

In order for many close support assets to accomplish detailed integration and employ their accurate munitions, they must first be able to reach the battlespace from the air. Therefore, a prerequisite for CAS is a sufficient degree of control of the air. In this, the Alliance is a victim of its own success. It's been over 65 years since Allied ground troops have had to question whether the air space in their vicinity was accessible by friendly aircraft. Historically, local air superiority is the minimum degree to be achieved for efficient CAS. Local air superiority refers to the ability of aircraft to operate close enough to the target area and the JTACs position to be controlled and be able to employ their weapons. Enemy air defences, such as defensive counter-air aircraft and surface to air fires may oppose friendly aircraft access[2]. There exists legacy TTPs that can provide sub-optimal close support in airspace that is opposed (called 'high-threat' or 'medium-threat' CAS) through minimizing the aircraft's exposure to the threat and utilizing the characteristics of certain weapons to increase the aircrafts' ability to release ordnance at an increased range from the target area. Unfortunately, most nations in the Alliance are not proficient at this type of close support simply because it's generally less efficient than 'low-threat' CAS, hasn't been required for generations, and the required military and political will to accept higher risks to aircraft and aircrew may be lacking.

As will be seen in the next section of the study, due to advances in capabilities, proliferation, and deployment of many modern air defences, this assumption of 'air superiority' may no longer hold true. The majority of

the Alliance's current CAS assets, including manned and unmanned systems, are relatively easy to detect and are vulnerable to these modern air defences. Additionally, traditional long-range weapons (such as glide munitions) are also vulnerable, further reducing the ability to provide weapons effects from the air while maintaining required stand-off distances. The next section of the study discusses the need for innovative use of emerging smart weapons and a re-examination and resurgence of the Alliances' high and medium threat close support TTPs.

3.2.4 Timeliness

In order for close support to be effective, the effect on the ground must be made quickly enough to provide the result the ground commander desires. Opportunities to create decisive effects are often fleeting. Enemy forces may only be exposed during short periods of time. Friendly forces may be taking effective fire from enemy units and unable to retreat to a more defensive position. A strategically important target may only be vulnerable for a short window of opportunity and be in a location requiring close support procedures. In all of these common scenarios, the ability of the JTAC and the close support asset to expeditiously establish detailed integration and coordination can determine if the effects are able to meet the ground commanders' intent. Some of the same building blocks required for previously described key elements of close support, such as robust and reliable communications in addition to common lexicon, standardized training, and established TTPs are essential to create a timely effect. Even within fairly recent coalitions, far too often aircrew and JTACs took too long to establish detailed integration because the conversation was bogged down by non-standard terminology or difficulty in understanding verbal communications due to either a language barrier or inconsistent/low fidelity communications systems. Additionally, JTAC and/or aircrew have caused excessive delays because of a lack of proficiency in operating their equipment and weapons systems. Potential solutions to these problems will be addressed later in this report, including maintaining appropriate training requirements (especially as the complexity of the weapons systems increase) and also participating as often as possible in international exercises involving close support.

1. CEP is defined as the probability that a certain percentage of weapon impacts will occur within a circular area, centered about the intended impact point. As an example, CEP90 could mean 90 percent of the weapons impact within the circle, while CEP50 means 50 percent impact within the circle.
2 https://www.doctrine.af.mil/Portals/61/documents/doctrine_updates/du_17_01.pdf?ver=2017-09-17-113839-373.

CHAPTER 4

Growing Spectrum of the Close Air Support Environment

The previous chapter outlined the history of CAS and identified key elements, highlighting their importance in providing effective close support across a spectrum of conflicts. In order to adequately set the stage for discussions focused on the future of close support, this chapter will succinctly describe projections about environment changes for future conflicts and what these changes may mean for NATOs employment of close support.

4.1 Political Guidance and Strategic Foresight

As a result of world events that occurred in the early-2010s, during the 2016 Warsaw Summit the Heads of State and Government (HOS/G) declared: 'the Alliance faces a range of security challenges and threats that originate from the east and from the south; from state and non-state actors; from military forces and from terrorists, cyber, or hybrid attacks. The greatest responsibility of the Alliance is to protect and defend our territory and our populations against attack. And so renewed emphasis has been placed on deterrence and collective defence.'[1]

Indeed, the latest NATO Strategic Foresight Analysis (SFA) addresses world characteristics beyond 2035, in terms of political, social, technological, economic, and environmental trends. The SFA describes many factors that will shape future trends including a global power shift from west to east, asymmetric demographic changes, rapid urbanization, increasingly polarized societies (especially in the developing world), access to Commercial-Off-The-Shelf (COTS) emerging technology, economic globalization, and climate change. Many of these factors may contribute to future conflicts. For instance, beyond the year 2035, urbanized conflicts are predicted to occur in the south and east regions of the western developed countries.[2]

© US Air Force, Courtesy Graphic

The A-10C incorporates a Situational Awareness Data Link, or SADL, able to join common tactical data links, such as Link-16.

While this assessment concludes that asymmetric conflict scenarios will continue, it also surmises that collective defence against a peer or near-peer adversary is increasingly likely. In addition, difficult, urbanized conflicts are a probable challenge of the future and both are likely to require reshaping and modifying the Alliance's current CAS operations.

4.2 Re-emerging Competitors

'The power of an air force is terrific when there is nothing to oppose it.'
Winston Churchill

Potential peer adversaries have studied western military capabilities and have developed (and are continuing to develop) robust Anti-Access/Area Denial (A2/AD) capabilities in response. These capabilities are tailored to deny the 'western way of war' by precluding access to what is arguably the west's most potent influencer – air power. The typical components of an A2/AD system include, but are not limited to, information operations, advanced highly-mobile Integrated Air Defence System (IADS), modern highly-mobile coastal defence missile systems, modern submarines, mines, precision air and sea strike, state-of-the-art Electromagnetic Operations (EMO), along with information and cyber operations. Advancements in space technology may also extend the capabilities of A2/AD, limiting Allied space capabilities in certain geographical locations[3,4]. The combination of these interoperable systems creates a substantial issue to achieving access to and maintaining a presence inside of areas where they are stationed[5]. Furthermore, many of these very capable systems are highly mobile, making it extremely challenging to achieve success in disabling critical nodes of the systems[6].

The layering of multi-domain defensive and offensive systems has given pause to Alliance planners and created doubt in NATO's ability to operate and be effective in these bastions. In particular, Russia has invested considerable resources into developing A2/AD capabilities and has carefully positioned their assets to maximize their strategic effect vis-à-vis NATO. In accordance with these precepts, Russia has recently enhanced their military posture, particularly in their littoral regions, with integrated air and missile defences, densely concentrated ballistic and cruise missiles, layered anti-submarine capabilities and forward-deployed forces. These defences are already firmly established at flashpoints and strategic areas such as Syria, Crimea, and Kaliningrad.

China is another resurgent military competitor and has likewise invested in overlapping state-of-the-art systems attempting to deny access across their spheres of influence[7]. China and Russia have also dramatically improved their EMO over the last decade, with modernized Electronic Warfare (EW) systems entering service across strategic, operational and tactical levels[8]. These systems have become key components of their strategic deterrence and information technology-enabled warfare.[9] These EW capabilities are also an integral part of their defensive systems creating a highly-contested environment. They are clearly tailored to target a broad set of frequencies and systems utilized in NATO's C4ISR infrastructure while being operated with highly automated and centralized command and control. They are also committed to creating systems that have the potential to detect low signature (stealth) aircraft[10]. With these systems, they may be able to detect Alliance fighters, bombers, and even low signature weapons that were previously considered extremely unlikely to be detected by traditional air defence radars.

The overlapping and redundant air defence bastions situated in key global locations, such as NATO's eastern and south-eastern flanks, and in the Asia-Pacific region, have the potential to remove the Alliance's control of the air (key element number three). Additionally, the robust EMO capabilities in and around these A2/AD areas have the potential to severely degrade and/or limit the level of detailed integration (key element number one) achieved due to communications jamming between the JTAC and close support assets and/

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or ground forces. These EMO systems also have great capabilities in degrading or eliminating the use of many of the Alliance's precision navigation systems, leading to less acceptable ordnance options due to a degradation in accuracy of these weapons (key element number two). In order to work through the challenges to the first three key elements, an increase in the time required to deliver effects will surely result. For many reasons, creating opportunities to practice advanced close support tactics to defeat communication and navigation jamming, along with high-threat CAS procedures (providing close support in contested airspace), is extremely difficult. The cost of obtaining and operating opposing force modern systems along with unintended effects for the civilian population in the area of the exercise makes this kind of 'high-end' training very rare. Unless the Alliance is able to adequately train to these contested environments, we will likely find ourselves completely unable to provide any type of close support in the early stages of the next near-peer conflict.

4.3 Current and Future Close Support Challenges

4.3.1 Urbanized Areas

The United Nations' 2014 report 'World Urbanization Prospects' estimated that more than 60 % of the world's population will live in urban areas by 2030 and it predicts a significant increase in Megacities (10 million or more inhabitants) in the years to come. These densely populated areas are characterized by significant horizontal and vertical growth. Horizontal growth is the increase in area of the city while vertical growth is the increase in area of midrise or taller buildings (MTB)[11]. These types of urban environments create difficult challenges when conducting close support. MTBs will often mask ground, airborne, and space-based sensors, creating large blind zones causing contact with enemy forces and friendly forces to be lost. These blind zones are exasperated when using fighter-sized fixed-wing assets since their line of sight

is changing more rapidly than slower aircraft, such as helicopters or unmanned aircraft. Collateral damage estimates are especially challenging in these areas due to the number of civilians and architecture material and subterranean infrastructure that can vary greatly over an extremely small distance[12]. Communication systems often have reduced ranges and less clarity due to physical and electromagnetic interference. Potential weapon choices can become very limited because the JTAC must consider how MTBs may interfere with the weapon's flight path and accuracy of the terminal guidance (whether space-based such as GPS and/or laser-guided). The Alliance has made great improvements in overall CAS efficacy in an urban environment since the 1993 UNISOM II Mogadishu city downing of two US MH-60 helicopters. However, as will be discussed in Part II of this report, capabilities and efficiencies in urban close support should continue to grow through leveraging technology advancements (especially when it comes to UAS) and through updates to Allied TTPs.

4.3.2 Communications and Common Picture Systems

In order to eventually focus on the communication possibilities for close support execution, we must first discuss how the Alliance is currently communicating during CAS operations. Even today, the majority of information being exchanged is accomplished through voice communications. Standardized communication 'bursts' have helped make these voice communications as efficient as possible. However, there are still many obstacles in the way of voice information exchange that are hard to overcome. An international coalition can bring very large obstacles in the way of language barriers, accents, and sentence structure. Adding to that are terminology and slang differences between services within the same country. In an attempt to solve these problems, the US established 'Air Land Sea Application Center' (ALSA) in 1975, with a mission to 'rapidly and responsively develop multi-service tactics, techniques and procedures, studies, and other like solutions across the entire military spectrum to meet the immediate needs of the warfighter'.

Radio calls remain the principal means of communicating during CAS execution. However, digital systems may expedite communications and, by extension, the target acquisition process. The intent of these Digitally-Aided CAS (DACAS) systems is to save time and mitigate operator errors associated with the receipt and transmission of targeting information in combat environments. To date, well-meaning but disconnected national and service efforts have resulted in disparate and largely incompatible DACAS technology[13]. Additionally, there has been a much-delayed acceptance that DACAS development efforts need to be coordinated across services and nations. Standardization has not occurred multinationally across JTAC schools, partly due to a large number of disparate national and service-specific communications networks for use in close support.

Gateways between the existing and future communications networks allow the networks to interact with each other and share information. Since 2001, gateways have existed within the Alliance creating a link between networks such as Situational Awareness Data Link (SADL) (through use of the Enhanced Position Location Reporting System (EPLRS) Radio), Link-16 (often referred to as Multifunctional Information Distribution System (MIDS)), and Variable Message Format (VMF) to communicate with each other.[14,15] While DACAS gateways are nothing new, the potential for improved robustness and for communication are far from fully developed. At present, there are many efforts to combine information from disparate networks, such as the USA's Integrated Tactical Network (ITN)[16]. These systems are being developed to better support all joint missions, including close support. Continuing to refine these types of gateways will be fundamental to achieving the required level of communication and information sharing for future close support operations.

4.3.3 Airspace

While conducting close support today and in the future, the use of airspace is required. The weapons system delivering ordnance and the ordnance itself must be de-conflicted from other friendly air assets in order

Army soldier incorporating the Integrated Tactical Network (ITN) system.

to prevent fratricide. Even considering our current CAS procedures with relatively limited platforms and short-range weapons, de-conflicting airspace commonly causes delays to achieving desired effects. When looking ahead to the possibility of contested airspace with numerous unmanned systems and long-range weapons providing close support, de-conflicting the airspace may be extremely challenging resulting in excessive delays to achieving effects. Simply de-conflicting airspace using spatial borders and time windows for air operations (such as corridors and ROZs) within those borders will greatly inhibit the efficacy of the close support effort.

Let's take an example. A friendly ground unit operating under contested airspace comes in contact with an enemy ground unit. Though the use of a future close support C2 system (that will be described in Part III), the best weapon to suppress the threat is determined to be a GPS-guided hypervelocity projectile fired from a ship near the coast, approximately 75nm away. Using today's procedures, and depending on the intensity of the conflict, coordinating the airspace (ensuring all Allied forces are moved out of the potential airspace used by the weapon) for a 75nm shot that transits altitudes from the surface to tens of thousands of feet could be next to impossible or take so long that the effects are not achieved in time to be effective. Future airspace control measures must be more flexible and dynamic in order to facilitate effective close support.

A July 2017 white paper published by the Joint Air Power Competence Centre, 'Air Warfare Communication in a Networked Environment', aimed to address this problem. The white paper introduced a concept called 'Dynamic Airspace Synchronisation' (DyAS). 'DyAS proposes the consideration of the battlespace as a resource that the networked platforms may synchronize through machine-to-machine data transfer.' DyAS achieves de-confliction of friendly forces by connecting all assets in the battlespace via a network that can track locations of assets and predict their probable future locations. Using this information, the airspace can be synchronized, allowing many assets to utilize airspace in close proximity to one another without traditional Airspace Control Order (ACO) rigidity. For example, instead of blocking off a large block of airspace for a single airborne asset to utilize in a close support scenario (preventing other effectors from being an option), DyAS would allow many assets to provide effects while still ensuring fratricide doesn't occur. The authors of the white paper state, 'DyAS could entirely replace the methods by which airspace control is executed in a joint battlespace.' For more detailed information, please reference the white paper.[17]

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Part II

Transitioning from Close Air Support to Close Joint Support

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German Light Armoured Reconnaissance Vehicle, 'Fennek', used by both Artillery Observers and Joint Terminal Attack Controllers.

CHAPTER 5

Joint Effectors on the Battlefield

There are more assets than just aircraft which are able to deliver weapons or provide other effects on the battlefield in a close support environment. Targets are selected based on the desired effect which is needed to achieve the (tactical) objective. With this in mind, we must change our thinking when considering providing effects in close proximity to friendlies to include all joint assets available. We must include all assets which have appropriate capabilities to meet the key elements for close support, as they relate to providing effects (integration, accuracy, and timeliness). The term CAS implies exclusion of other than air-delivered effectors. In order to include the entire list, this study purposes the name to describe future close support missions should be changed to Close Joint Support (CJS). The word 'Close' remains to ensure the difficult challenges of applying effects in close proximity to friendly forces are represented. However, as we will see in the following chapters, the word 'joint' needs to be included to acknowledge that future effects will come from the full spectrum of joint capabilities and assets.

In Part I, the authors described how the Alliance has been focused only on close support TTPs for a permissive environment, while basically neglecting high-threat close support training. In essence, our ability to conduct low-threat close support is dwindling due to ageing and reduced numbers of assets and dogmatic approaches to the use of current capabilities, while our high-threat close support capability has atrophied.

If leveraged properly, current and future technologies have the potential to help with these issues. NATO must reconsider some of the traditional paradigms of the past. Acknowledging fiscal constraints among partner nations, this chapter presents ideas about leveraging current capabilities to potentially help with asset density and access in a near-peer conflict, which includes breaking down dogmatic barriers among services. The fact is that 'air' is not the only tool available to ground forces to provide effects '[…] against hostile targets that are in close proximity to friendly forces and which require detailed integration […]'. What follows are descriptions of current air assets and future multi-domain assets that have the potential to contribute to supporting forces in the close support mission.

5.1 Manned Fixed-Wing Aircraft

5.1.1 Legacy Aircraft

In order to keep from discussing the specifics of 'aircraft generations' (such as 3rd, 4th, and 5th) in this report, we will categorize 'legacy aircraft' as aircraft that were not designed and manufactured from their inception with a main focus of effort on creating a very low radar signature ('stealth'). 'New-generation' aircraft will be the category that includes only aircraft that were conceived and manufactured with a main focus of effort on creating a traditionally very low radar signature. Other advantages found in new-generation aircraft include advanced active and passive sensors, advanced TDLs, and advanced multi-spectral information fusing. The majority of these aircraft systems and computer processor driven improvements have been, or are currently being, designed into existing legacy aircraft. However, the main capability that new-generation aircraft have that can't be transferred to legacy aircraft is their level of very low radar signature.

Over the last 50 years, fixed-wing manned aircraft were the foundational enablers of close support operations in almost every NATO campaign. In particular, aircraft such as the A-10, F-15, F-16, F/A-18, Harrier, Mirage, Gripen, and Eurofighter have conducted the majority of fixed-wing close support missions. These aircraft have capabilities that can be characterized as having medium-range, operating in medium to high altitudes, with relatively high ground speed, while carrying an average payload and operating from medium sized airbases and/or aircraft carriers *(The A-10 is an outlier for some of these mentioned 'characteristics' as they are generally able to bring a larger payload, have increased loiter time, and slower ground speed).* These aircraft are by far the most abundant aircraft available for close support missions within the Alliance and will continue to take the lion's share of close support missions involving manned aircraft in future low-to-medium risk environments.

Apart from agile fighter aircraft, bombers have also been a considerable close support contributor. Large bombing platforms such as B-52 and B-1 have flown close support operations for almost two decades. These aircraft can be characterized as flying at high altitude with very long combat radii and being capable of delivering an extremely robust payload, albeit from larger and less numerous airbases.

The legacy aircraft inventory is steadily shrinking. Based on a study on worldwide fighter aircraft programs, including NATO countries as well as Australia, Israel, Japan, South Korea, and Taiwan, the 2018 total of 5,523 legacy fighter aircraft will have dropped to 4,344 by 2027[1]. That's a reduction of 21 percent in just ten years. Additionally, the average age of these aircraft is steadily climbing, with only a handful of nations procuring substantial quantities of new aircraft.

Legacy aircraft will continue to play a critical role in filling close support requests for any conceivable scenario. They are capable of maintaining lethality and acceptable survivability for conditions short of highly contested environments. However, current TTPs are focused almost completely on permissive situations. The vast majority of training sorties do not consider any credible threat in the target area and as such aircrews and controllers are not prepared to effectively conduct close support in even medium threat conditions. As a result, only the new-generation aircraft, such as the F-22 and F-35, are considered survivable in many current and future non-permissive environments.

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5.1.2 'New-Generation' Aircraft

When conducting close support operations within contested airspace, advanced fixed-wing aircraft, such as the F-35, may be the only survivable manned option as currently fielded and using current tactics. There are three variants of the F-35. The F-35A is Conventional Take-off and Land (CTOL), the F-35B is Short Take-off Vertical Land (STOVL), and the F-35C is Catapult Assisted Take-off Barrier Arrested Recovery (CATOBAR). The F-35B has a demonstrated combat radius of over 500 nautical miles, with the F-35A and F-35C demonstrating well over 600 nautical miles[2]. The combat radii listed are calculated without Air-to-Air Refuelling (AAR). Although the F-35 will likely lose its low-observable characteristics during the process of conducting AAR, they have the ability to fill up their fuel just prior to entering, and soon after leaving a contested airspace, thereby increasing their operational range into that airspace and/or substantially increasing loiter time. This should permit F-35s to conduct missions near the heart of contested airspace while operating from bases (including aircraft carriers) located outside the range of the adversaries' systems. Unmanned refuelling aircraft[3] may prove to be a perfect companion for these types of missions, providing pre-mission and post-mission fuel. Additionally, the F-35 is designed to be able to penetrate into contested airspace and obtain precise location data of key A2/AD nodes (that are highly mobile) and then pass this 'real-time' target location to legacy aircraft operating outside the A2/AD bubble. Legacy aircraft and surface-based platforms should be able to launch long-range, 'networked' weapons to interdict these key nodes. Especially when considering the high mobility of many key nodes, new-generation aircraft may be required to provide terminal guidance and/or target location updates during the time of flight of the long-range weapons in order for the weapon to successfully engage the node. With adversary air defences degraded, even for short periods, legacy air assets should be able to support ground forces while maintaining an acceptable level of survivability.

Within the coming years, 'new-generation' aircraft are expected to be available in large enough numbers to substantially contribute to Allied air power and enable legacy platforms to continue to be effective. However, the total number of 'new-generation' strike capable

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aircraft will only be a small percentage (20–30 %) of the total Allied fighter inventory[4]. They will also be in high demand across a wide range of missions, only one of them being close support. That being said, while these new-generation aircraft may not always directly execute close support, they will be a key enabler for CJS by helping create permissive windows for legacy aircraft and long-range joint weapons to penetrate the airspace and provide the desired effects.

In order for new-generation systems to reach their full potential as a force enabler, they must be fully interoperable with legacy aircraft and other CJS capable systems. There are on-going efforts being conducted by many agencies associated with NATO nations, including the European Air Group (EAG) and NATO AIRCOM, which are focused on ensuring the F-35 is interoperable with legacy platforms, including Tactical Data Links (TDLs), existing airfields, and existing NATO-led exercises and training[5]. The level of capability brought with the aircraft will in large part be determined on how successful the aircraft is integrated into current NATO air forces, including Air C2 systems, shared TDLs, and employment TTPs.

Despite the potential for new-generation aircraft to add great capabilities in the close support environment, concerns with over-reliance on these airframes in the future remain. With legacy fixed-wing aircraft retiring and being replaced at less than a 'one-for-one' ratio by new-generation aircraft, there could be a substantial shortfall in available fixed-wing CAS-capable aircraft. Considering the cost of procurement and operating fighter-attack jet aircraft (legacy or new-generation), many Allied countries are looking for affordable solutions to provide close support in permissive environments, which will be discussed next.

5.1.3 Light Attack Aircraft

A solution many countries are considering is the use of Light Attack Aircraft (LAA) to conduct a variety of missions in permissive, low threat environments. Examples of current LAA aircraft include the A-29 (or EMB 314) Super Tucano and the AT-6 Wolverine, a light attack variant of the highly proliferated T-6 Texan II trainer aircraft. Although LAA are being considered for missions such as counterinsurgency (COIN), armed over-watch, Counter-UAS, and Intelligence, Surveillance, and Reconnaissance (ISR), they have great potential to be an extremely effective and affordable platform to conduct close support.

Emerging battlefield conditions indicate that LAA may have a significant role in close support operations of the future. Indeed, ongoing counterinsurgencies virtually ensure that aircraft optimized for low threat environments (such as LAA) will be valuable assets for the future fight. More specifically, LAA embody many of the attributes a 2005 RAND Corporation study found desirable in close support aircraft[6]. These include long loiter time, quick turn rates, mixed weapons loads, accurate weapons delivery systems, and the ability to operate from unimproved bases. LAA have the potential to be much better than traditional fighter aircraft in most of these categories. They also have the potential to be based in more effective locations when considering their less stringent base requirements and smaller logistics and supply chains, as compared to strike-fighter aircraft.

The capabilities listed above come at a much-reduced price, when considering the cost to procure and operate a strike-fighter aircraft. To get an idea of the savings, for Fiscal Year 2019 the USA Department of Defense charged approximately USD 1,800 per flight hour for external use of the T-6A/B. They charged USD 13,000 for the F/A-18F, and USD 18,000 for the F-35A (or ten times the hourly price of the T-6)[7]. When considering the substantial number of flight hours required to train aircrew in the close support mission, the difference in cost to train LAA aircrew versus an F-35 pilot is substantial, let alone the saving that will occur during combat sorties. Besides the much-reduced cost of the procurement and operation of LAA, they have the potential to augment asset shortfall when considering the reduction of fighter aircraft and the potential for these fighter aircraft to be in high demand across the spectrum of air power missions. LAA could be used to take the niche low-threat CJS role in many scenarios, allowing fighter aircraft to carry out other missions.

In summary, while LAA are not survivable in contested environments, they may be optimally suited for many ongoing and future low threat operations and can provide relatively low-cost close support. It is in this context that many Alliance members are considering adding LAA to their arsenal.

5.2 Manned Rotary-Wing Aircraft

Attack helicopter history traces its origins to the Vietnam War. It was then that the US Army felt the need to develop new platforms specifically tailored and centred on the execution of close air support and anti-armour capability[8]. It was this need that drove the US Army's aircraft advancements during the Vietnam War, resulting in a transition from the armed Utility Helicopter (e.g. UH-1) gunships to the development of the first dedicated attack helicopter, the AH-1 Cobra.[9] Following the US Army's lead, other countries began to develop indigenous attack helicopters to obtain the same capabilities.

Today's attack helicopters can employ a wide arsenal of weapons (cannons, machine guns, rockets, anti-tank missiles, and air-to-air missiles) along with advanced sensor suites for target acquisition and night vision systems. As far as close support is concerned, NATO defines rotary-wing attack aircraft as 'an excellent capability to conduct CAS in diverse terrain and when accompanying other transport or rescue assets … [aircraft which] can often operate effectively under low ceilings that might render fixed-wing aircraft CAS ineffective, while fixed-wing aircraft can operate above …'[10]

Nevertheless, when using rotary-wing attack aircraft in the close support mission, they are often limited by training or policy of individual nations, rather than their aircraft capabilities. Indeed, NATO TTPs for CAS and Air Interdiction (AI) state, 'NATO members and their respective armed services may or may not consider rotary-wing aircraft as (capable of) performing CAS. Some may operate under Close Combat Attack (CCA) guidelines and therefore may not require a JTAC to execute the mission.'[11]

CAS and CCA are similar in desired effects, but with the main difference being that when performing CCA, final release authority lies with the pilot, vice a JTAC or

FAC(A). CCA is defined as, 'An attack [...] providing air-to-ground fires for friendly units engaged in close combat'. When operating in CCA, the helicopters will be part of the combined arms team. In this way, as stated in NATO ATP-49, 'due to the unique capabilities of aircraft and the enhanced situational awareness of the aircrews, final guidance from ground units or controllers is not necessary'.[12]

Further, NATO doctrine clearly states 'When helicopters are organic to Corps, Divisions and Brigades as part of a combined arms team, land force commanders normally do not consider Attack Helicopters as CAS assets'.[13] Army helicopter units normally operate as an integral manoeuvre element under the control of a manoeuvre commander. Undoubtedly, CCAs grant the land force commander great freedom of action. However, 'when attack helicopters are tasked to work with other units without having been in an in-depth planning process, the preferred method of controlling the aircraft is by using CAS procedures'.[14]

In recent conflicts, rotary-wing CAS/CCA has only been utilized in lightly contested air space with the primary threats being guns, Man-Portable Air-Defence Systems (MANPADS), and Rocket-Propelled Grenade (RPG) launchers. Nonetheless, battles over the last two decades have shown that rotary-wing aircraft have unique characteristics that help them gain enhanced tactical situational awareness and strike targets that are more difficult for faster-moving aircraft[15]. Building upon those capabilities, future combat rotorcraft will likely provide superior speed, range, and payload performance[16]. Sikorsky and Boeing, for instance, have joined forces to develop the SB>1 DEFIANT™, the next-generation rotorcraft of the US Military. Having a compound coaxial rotor with a pusher-propeller in the back, the aircraft has the potential to fly twice as fast and twice as far as many of today's conventional helicopters.[17] The SB>1 is also reported to have enhanced low-speed manoeuvrability and exceptional hover control, decreasing susceptibility to traditional helicopter threat systems.


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Artist's rendering of the SB>1 Defiant.

Manned-Unmanned Teaming (MUM-T), as described in the next chapter about UAS, is already being employed by the AH-64E, and will increase overall situational awareness of friendly forces, while helping to reduce the risk of collateral damage and fratricide.

In the end, CJS provided by rotary-wing assets could be considered an economical and effective method of supplying close support in a wide range of operations. Furthermore, close support helicopters operating generally at lower altitudes, and having a different arsenal of weapons than fixed-wing aircraft can provide a complementary capability to other air, land, sea, and space assets.

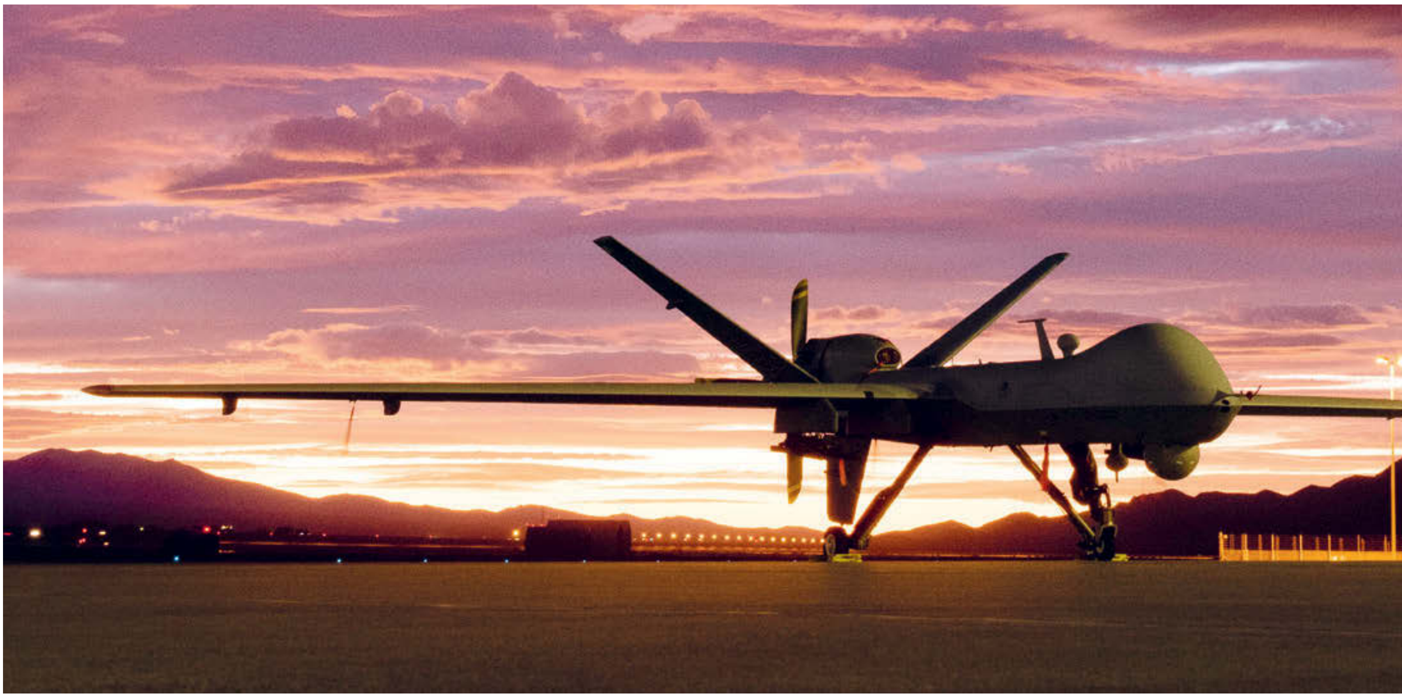
5.3 Unmanned Aircraft Systems

Since their first employment two decades ago, Unmanned Aircraft Systems (UAS)[18] have become an integral part of almost any air strike mission. During Operation Enduring Freedom[19] Predator UAS were armed with Hellfire missiles for the first time, killing key Taliban and al-Qaeda decision-makers responsible for the attacks of 11 September 2001. Since then, UAS have become an integral part of military efforts in Afghanistan, Syria, and Iraq, establishing a new era of unmanned close support.[20] Although reconnaissance and strikes against high-value targets continue as staple UAS missions, close support has become a regular and growing requirement. In Iraq and Syria, over the calendar year 2016 alone, MQ-1s and MQ-9s deployed over 1,500 weapons against ISIS on the ground, many of which were employed in CAS situations.[21]

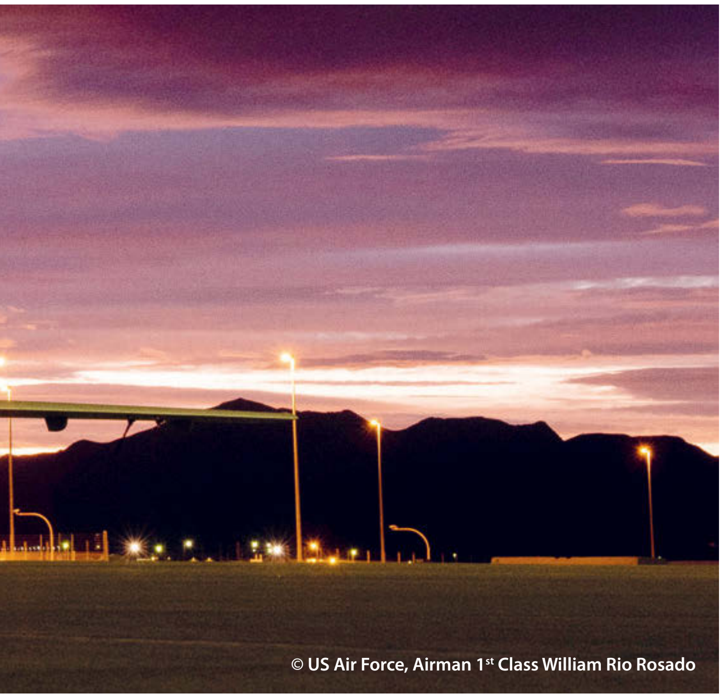
UAS enable the pilots and sensor operators to be remotely located, working in shifts, allowing for mission durations limited only by the fuel consumption of the aircraft. UAS also eliminate the possibility of losing aircrew in contested environments, making them the preferred asset in many tactical scenarios including medium-to-high risk CJS.

5.3.1 Manned-Unmanned Teaming (MUM-T)

To further enhance the operational use of unmanned systems, the MUM-T concept was initiated in the early 2000s with the aim to provide ground forces, and pilots in fixed or rotary-wing aircraft, with the ability to receive imagery from the UAS' sensors[22]. Today, UAVs



are able to share real-time video with JTACs, FAC(A)s, and manned CAS assets through this concept. Some UAVs also are able to provide target laser designations for weapons employed by a different asset while also able to guide their own munitions.[23] UAV's with a small, integrated warhead, designed to be flown into a target, have also been developed that can be controlled by ground forces, with future models aspiring airborne control.[24] This is significant in that it may be an excellent option to create CJS effects for targets that are difficult to discern from ground or airborne manned positions, and could dramatically reduce collateral damage estimates, when compared to the majority of traditional weapons. MUM-T could also enable legacy aircraft to operate at standoff ranges and monitor actions on the battlefield without being in acoustic or visual range, while still within range to provide kinetic effects, if required.[25] Additionally, new MUM-T concepts aim to incorporate command of the UAS itself into manned aircraft so that the pilot has direct control over its sensors, flight manoeuvres and weapons.[26] This capability has the potential to reduce the dependency of SATCOM-based links while allowing the aircrew (with potentially better situational awareness) to handle the UAV control instead of Ground Control Station personnel. This capability will need to be incorporated carefully, as to not add excessive workload to the aircrew.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5.3.2 UAS Electromagnetic Operations (EMO)

While a somewhat new concept when considering the close support mission, UAS with Signal Intelligence (SIGINT) sensors can be used to find, fix, track, and target critical nodes of the systems attempting to deny Allied access. UAS may also carry equipment that are able to employ Electronic Counter Measures (ECM) and/or provide Electronic Warfare (EW) effects in preparation for, or during, CJS operations; degrading and disrupting enemy communications, Supressing Enemy Air Defences (SEAD), or hunting and locating critical A2AD nodes[27]. This application of UAS could also complement the SEAD effects of anti-radiation missiles (ARMs), designed to detect and guide to a specific or group of emitters. The long loiter time possible with a group of armed UAVs[28] could provide a long window of time for CJS assets to infiltrate the area and provide close support while enemy radars are kept from radiating due to the anti-radiation UAV threat. As such, UAS with EMO capabilities may eventually play a very important role allowing CJS weapons to provide effects in contested environments.

5.3.3 Air-to-Air Refuelling (AAR)

New concepts in UAS experimentation which may affect close support include unmanned Air-to-Air Refuelling. For example, the US Navy's MQ-25 is currently being tested as a carrier-based tanker aircraft which will accompany maritime strike and CJS aircraft on their missions. The amount of available fuel that the MQ-25 will be able to pass is on par with the current carrier-launched manned refuelling aircraft (the F/A-18E/F), however the MQ-25 will have much longer loiter time once on station. The use of the MQ-25 and other UAS AAR aircraft to provide tanker support to carrier-based close-support aircraft will undoubtedly lead to more close support being supplied by maritime aircraft and may provide an alternate route to access close support missions in contested environments.

5.4 Artillery

Artillery units, typically attached to army brigades or divisions, provide organic fire support of these ground manoeuvre elements.

With the end of the Cold War, the probability of high-intensity battles against a peer opponent became increasingly unlikely, leading to a negligible role for artillery in an asymmetric conflict, and, in turn, a significant reduction in artillery systems in NATO. For example, just the German Armed Forces alone reduced their inventory from over 150 artillery battalions in 1980 to currently four battalions in 2019.[29] However, the advent of the Global Positioning System (GPS) in the early 1990s, coupled with the ever-increasing speed and miniaturization of computer technology as well as the emergence of digital communications, marked a turning point in the development of modern artillery systems and their ammunition. Modern artillery guns such as the German 'Panzerhaubitze 2000' and rocket launchers such as the US 'Multiple Launch Rocket System' (MLRS) combine mobility with fast and precise kinetic effects, and they are highly integrated with ground forces to coordinate the indirect fire with the scheme of manoeuvre. Some of the contemporary advantages of artillery systems include:

5.4.1 Mobility

The mobility of artillery units does not mean that they merely can move quickly. Instead, mobility implies that the weapon system knows its position and orientation at any given time in order to execute fire commands without further preparation and that it can leave its fire position immediately after, leaving it empty for enemy counter fires. Until well into the 1980s artillery systems were quite static, had to be set up in a cumbersome manner, and firing positions needed to be surveyed in advance, and adjustment of fire was required.

5.4.2 Speed

Today's artillery fire support can be provided within single-digit minutes of being requested. Modern howitzers and rocket launchers compute their own ballistic trajectories based on the digital transmission of target coordinates. Depending on the density of artillery units, they have been able to provide effects faster than CAS due to less coordination and/or closer proximity of the supported unit.

5.4.3 Precision

Artillery fires are traditionally inaccurate. This dispersion is measured as the Circular Error Probable (CEP) and results from a variety of environmental factors affecting the shells or rockets on their trajectory. Modern systems minimize many of these factors through precise corrections for metrological and internal measurements. These measures can reduce the CEP to a few metres, whereas legacy systems had CEPs of up to 50 metres and more. GPS-guided artillery rounds such as the 'Excalibur' can provide the same level of accuracy as any other guided ordnance, but they come at an approximately 30 times higher cost per round if compared to regular shells.

5.4.4 Integration

In the same way as JTACs coordinate CAS, Artillery Observers (AO) accompany the ground forces and are embedded at the company level. Modern AO's equipment includes a laser rangefinder and digital radio to submit target coordinates to fire direction centres or even directly to an assigned firing unit. Release authority for requested artillery fire also lies with the AO. Depending on the trajectories of artillery fires, close coordination with airspace control centres is required to clear the airspace of friendly forces. Therefore, AOs are often co-located with JTACs or are occasionally trained as JTACs, combining both qualifications.

Considering these advancements in accuracy, timeliness, and the inherent advantage of integration with organic forces providing the artillery effects, artillery has the potential to provide very effective CJS in many situations, especially those where air superiority is not achieved.

5.5 Naval Surface Fire Support (NSFS)

Naval warships have conducted shore bombardment for over 500 years[30], however only since the Second World War has technology advanced far enough to consider using naval gunfire in close proximity to friendly forces. One example of this was during the Allied Normandy invasion in 1944, at the heavily defended invasion site called 'Omaha Beach'. As the landing forces moved inland, they took heavy casualties and progress eventually stalled due to effective fire from German gun emplacements. Consequently, United States destroyers, battleships, and cruisers used naval surface fire support to destroy and disable the German defences with friendly forces in close proximity, thereby enabling the assault to advance. Colonel S. B. Mason, Chief of Staff of the 1st Division US Army wrote of the invasion, 'But there was one element of the attack they could not parry. […] I am now firmly convinced that our supporting naval fire got us in; that without that gunfire we positively could not have crossed the beaches.'[31]

Modern naval gunfire can provide substantial effects on the battlefield, assuming certain conditions exist. The first is that the ship can be positioned such that its ordinance can reach the intended target. Currently, naval gunfire support can reach targets in the neighbourhood of 15 miles inland from the water[32]. Also, naval surface fires suffer the same accuracy challenges as land artillery, often compounded by a moving, rolling platform. Although these are indeed current limitations, projects to improve both the range and accuracy of naval gunfire are well underway, with considerable improvements on the horizon.

In the future, higher velocity projectiles, fired from either current conventional guns or future electromagnetic rail guns (EMRGs), will significantly increase the range naval gunfire can travel. One example is the Hypervelocity Projectile (HVP),[33] which has a reported range of 40 to 70 miles, depending on the size of the traditional gun used to fire it.[34] In the not so distant future, EMRGs should be able to send ordnance out to approximately 100 miles.[35] Technology is improving rapidly to make these long-range projectiles extremely precise as well. Some new types of precision include GPS mid-course guidance, with projected improvements including terminal guidance being provided by either a laser designation or a millimetre wave seeker (examples include the HVP, M712 Copperhead laser-guided projectile, the M982 Excalibur GPS-guided round, and the Long-Range Land-Attack Projectile[36]).

USN firing Mach 3 guided round from a standard deck gun.

When considering contested environments, even at extended ranges of 40–100 miles, many ships may still be kept from getting close enough to provide NSFS. However, many Allied countries are investing in 'stealth ships' that could enable acceptable survivability inside of highly contested waters. The US Navy's newest destroyer, the Zumwalt class, has a low radar cross-section design with naval gunfire support as one of its primary missions. Even with the many programmatic challenges of the Zumwalt[37], the Zumwalt class destroyer and future ships should be able to provide ordnance at long enough ranges, and with enough accuracy, that they could provide CJS in many scenarios.

Lastly, like land artillery fires, one of the main problems with utilizing long-range projectiles from naval vessels is clearing the airspace from friendly aircraft. Although naval gunfire has a traditionally low trajectory, and thus peaks at relatively low altitudes (normally below fixed-wing operating altitudes), as the ranges of shots increase so will the altitude of the projectile. When calling for NSFS, JTACs may find that the task of clearing the expansive airspace for the shot (including medium altitudes where fixed-wing aircraft traditionally reside), is challenging.

While potential airspace control problems as well as cross-service communications issues are likely to remain a challenge for the near future and beyond, there are looming technological opportunities which may enable NSFS to be effectively integrated into the joint fight. Situations where air assets will be placed at high risk due to IADS (especially if the coastal defences are limited), or where the density of available and survivable air assets are low, NSFS may play a significant role in providing CJS. Because of this great potential, efforts should continue to advance affordable, long-range and precise NSFS. As shown in previous wars, NSFS could play a pivotal part of Allied success.

5.6 Emerging Capabilities and Technologies

Current world political-social-economical-environmental factors indicate that many operating environments are being transformed. Modern world conditions have led to technological evolution across many new warfighting domains, including space and cyberspace. Militaries across the world are working on low observable and unmanned technology, robotics, artificial intelligence, big data and information, biomimetic, nano-technology applications, and swarming technology. Many of these advancements already exist on the battlefield, and their proliferation will increase exponentially in the coming decade, both inside of NATO and its allies as well as the militaries of potential adversaries. As such, NATO close support operations must continue to evolve through utilization of this emerging technology. The following emerging technology section is offered to discuss how some of these technologies are currently being leveraged in an attempt to improve the efficacy of future CJS.

5.6.1 Networked Stand-Off Weapons

As previously discussed, the proliferation of technology creating contested operating environments has triggered NATO countries to develop systems to improve force survivability. Establishing survivability for assets to operate inside contested airspace is extremely difficult and provides a great risk to the asset. Another option for providing support to ground forces is through utilizing offensive weapons with long enough ranges to keep the air asset outside of the contested environment. Continued advancements in surface and air-launched weapons, such as *hypersonic* missiles, are imperative to accomplish this. For example, *supersonic* air-to-ground missiles can be launched with a range of up approximately 500 kilometres, only marginally more than Russia's S-400's current declared range of 400 kilometres. However, air-launched *hypersonic* missiles could cover a range of approximately 1,000 kilometres (and in 10 minutes at Mach 5), maintaining the launching platform outside long-range SAMs.[38] As stand-off air-to-surface missile technology improves, it will be imperative that their employment to support troops inside of contested environments be developed. Assuming the weapons are 'network-enabled', the JTAC could update target coordinates during the time of flight, including changing the type of selectable fusing option for the warhead post-launch. Additionally, there is currently substantial effort being given to design the proper warhead for these hypersonic weapons, allowing for customizable fragmentation patterns while decreasing the potential for Unexploded Ordnance (UXO)[39]. Utilizing these technologies, the weapons' effects may be effectively mitigated, allowing for hypersonic weapons to be a viable option in many CJS situations.

In certain scenarios, smaller (and cheaper) air-launched stand-off glide weapons could be used to penetrate areas of medium to high contested airspace. An example of this type of weapon is the AGM-154, Joint Standoff Weapon (JSOW)[40]. The newest variant of the JSOW is able to be launched at unclassified ranges of around 70–100km and has a two-way strike common weapon datalink allowing other members in the network to provide real-time target updates to the weapon. The newest concept, called the JSOW-ER, incorporates a small turbojet engine for propulsion and may have a range of approximately 500 km. All versions of the JSOW also are low observable, making them hard to detect and counter by adversaries IADS. JSOW can be carried internally by the F-35[41], leading to the potential to release the weapon well inside air defence envelopes. Finally, JSOW has multiple options for terminal guidance, including precise GPS or thermal imaging. When considering conducting CJS inside highly-contested airspace, these relatively cheap[42] weapons could be launched from aircraft receiving initial targeting from a JTAC, and then be updated during the time of flight directly by the JTAC leading to a precise engagement while keeping aircraft outside the weapon envelopes of the adversary.

5.6.2 Directed Energy Weapons

Directed Energy Weapons (DEW) are electromagnetic systems capable of converting chemical or electrical energy to radiated energy and focusing it on a target, resulting in physical damage that degrades, neutralizes, defeats, or destroys an adversarial capability[43]. Although many weapons could fit into this category, our focus in this report will be mainly on High Energy Lasers (HEL), Electromagnetic Pulses (EMP), and High-Power Microwaves (HPM).

5.6.3 Lasers

Although research has been conducted since the 1960s on the use of high energy lasers in a military application[44], only recently has there been the technology to enable lasers to become a useful tool for soldiers across all physical warfighting domains. In February 2018, the US Navy awarded Lockheed Martin Aculight a $ 150 million contract to develop a deployable laser, called High Energy Laser and Integrated Optical-dazzler with Surveillance (HELIOS), for the Navy to integrate into resident systems on surface vessels. 'We've now reached the point in laser development [where] you can have an effect on the adversary and the adversary's systems at an operationally important range', says Rear Admiral Druggan, Commander of the Naval Surface Warfare Center[45].

HEL technology will shortly allow fighter-sized platforms to use lasers in self-defence, destroying or disabling missiles that are targeting their aircraft. Systems under development such as the US Air Force's Self-Protect High-Energy Laser Demonstrator, or SHiELD, have the goal of incorporating a high energy self-defence laser into fighter-sized aircraft such as the F-15 early in this decade, with the first technology demonstrator slated for trial in 2021[46]. Assuming this technology becomes highly reliable, it could potentially allow more CJS assets to access contested environments, thereby increasing the options for effects available to the ground commander in an A2/AD environment. However, due to the technological challenges of fielding HEL on fighter-sized aircraft[47], the use of HEL to provide direct effects on the ground from fighter-sized assets is still likely still a few decades away[48]. Within this decade, however, it may be possible that large attack aircraft such as the AC-130 would be able to employ lasers with enough power to have good effects on ground targets[49], especially soft targets vulnerable to HELs in a low threat environment.

5.6.4 Electromagnetic Pulses and High-Power Microwaves

Although EMP and HPM technology may be on the cusp of providing a very capable and crippling electromagnetic bomb, or 'e-bomb', to the adversaries' communications and the majority of their sophisticated weapon systems[50], these types of EM weapons will have to be used carefully in the CJS environment. EMP and HPM will have to consider larger collateral damage effects than weapons such as HELs. Although their use may be very advantageous in many warfare scenarios, the use of EM pulses and HPM in the close support mission could result in significant damage to friendly weapon systems and civilian infrastructure.

A well-developed DEW, able to be utilized in a CJS environment would have great potential to revolutionize close support effectiveness while reducing collateral damage. DEW have the potential to be extremely accurate and provide surgical effects, only effecting a specific type of system or target. They also are able to begin providing their effect immediately upon releasing energy from the DEW source. Roadblocks in the future use of DEW include considering ethical and legal guidelines provided in the Law of Armed Conflict (LoAC), such as restrictions on weapons that can cause blinding or maiming[51].

5.6.5 Drone Swarms

In the future, multiple expendable UAS may be grouped in a swarm and employed as decoys to deceive, congest, or saturate enemy air defence radars. As an example, the US Air Force Research Laboratory (AFRL) has requested Lockheed Martin and Northrop Grumman to produce swarms of autonomous low-cost cruise missiles.[52] Not only can these missiles saturate an enemy air defence system, but there is also potential for these missiles to be used against defended targets or supplement traditional close support effectors when the density of CJS assets are low. These missiles are designed to utilize their low observability characteristics and synchronized swarming, using flight profiles that make them hard to detect and engage. This type of swarm attack also has the potential to target multiple objects simultaneously, however, the challenge of determining collateral damage estimates from employing a swarm-sized number of missiles has to be done carefully in order for this type of weapon system to be useful in even a minority of CJS scenarios.

A high-energy laser system on an AH-64 Apache attack helicopter.

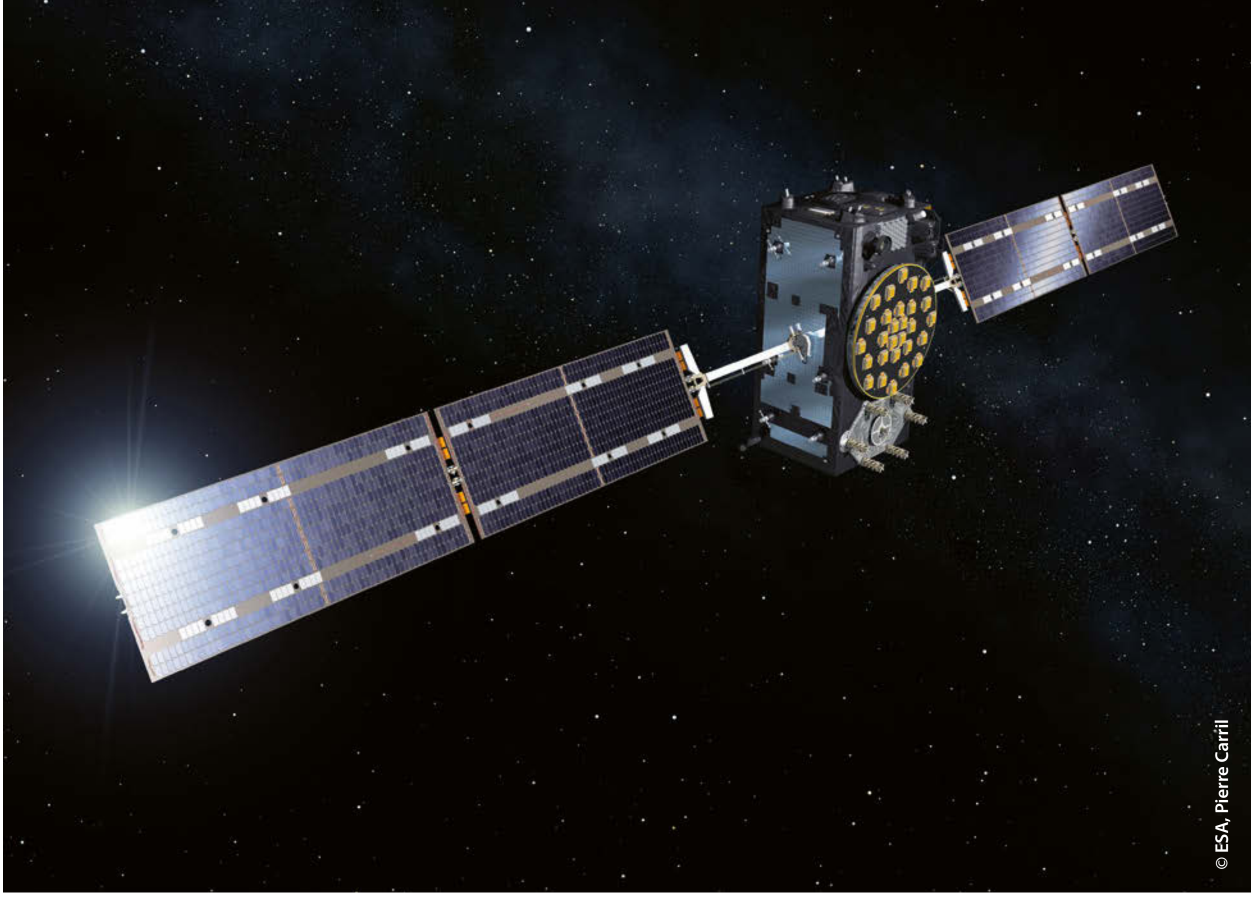
5.7 Space-Based Capabilities

Considering the extremely capable equipment, technology, and personnel conducting combat across all domains and the majority of mission sets, the reliance on space-based systems to fully utilize TTPs has increased exponentially over the last decade. There are three space-based capabilities that can have critical importance to the execution of CJS. These are Satellite Communications (SatCom); Position, Navigation and Timing (PNT); and space-based Intelligence Surveillance and Reconnaissance (ISR). While SatCom and ISR can be provided by several assets from various NATO nations, due to an official memorandum of understanding, PNT is currently only obtained using the Global Positioning System (GPS) which is operated by the US Space Force. Effective CJS execution requires all of this support from space, albeit at various levels of importance. The next section will break down each of these capabilities, discussing current and future considerations as they pertain to close support.

5.7.1 SatCom

SatCom services primarily utilize satellites in GEO[53] and are needed for communication when there is no direct Line of Sight (LOS) available or the distance between receivers combined with EMS environmental factors cause the radio frequency to be unusable. Airborne CJS assets operating at very high altitudes may require SatCom to effectively communicate due to these LOS factors. In some situations, such as UAVs performing CJS, SatCom services are likely the only available communication due to the command and control systems of the UAV.

Looking to the future, there is a possibility that SatCom could be provided from large-scale constellations of satellites in LEO[54], comprised of dozens of satellites in an individual constellation versus the current situation of a hand-full of satellites that establish the GEO SatCom constellation. These LEO SatCom constellations have the potential to increase LOS space



communications capabilities including increased robustness and clarity of the signal.[55] Especially when considering an EMO dense situation, such as an urban environment or in contested airspace, increasing robustness could determine if reliable communications are able to be established between the JTAC, MDC2S, and the CJS asset.

5.7.2 Position, Navigation, and Timing

Synchronization between assets is provided through PNT and is required for most communication networks, advanced encrypted communications, along with aircraft and smart-weapon PNT systems. Space-based systems will continue to provide these services for the foreseeable future, and will become more resilient due to improvements in newer versions of GPS satellites and the potential addition of the European Union (EU) PNT system GALILEOs Public Related Service (PRS).[56, 57]

5.7.3 Intelligence, Surveillance, and Reconnaissance

Space-based ISR currently plays no role in CJS operations due to long lead times required to obtain space-based ISR information. The procedures to task a sensor, collect the requested data, pass the data through the assessment process, and finally transmit the assessed data to the tactical level soldier is usually too cumbersome and requires too much time to be tactically relevant. As technology and capabilities improve in space and on the ground, being able to collect 'real-time' space-based ISR could become another avenue to provide overall situational awareness to ground commanders in close support situations.[58]

5.7.4 Counter-Space

As with most support services, space-based support for close support operations is not guaranteed. SatCom and PNT services can be degraded or denied accidentally by unintended interference within Allied systems or purposely by an adversary. Similarly, ISR services can be interrupted, but the techniques generally require sophisticated procedures and supporting services, the type only available from a peer opponent. The worldwide development of various jamming capabilities, as well as the proliferation of technology behind such capabilities, has resulted in a substantial effort by NATO to maintain persistent service. In November 2018, the NATO Parliamentary

Assembly insisted that the Alliance needs to develop a more focused space policy[59]. Peer NATO competitors have already demonstrated counter satellites capabilities. Analysts have noted that Russia, China and India have developed destructive anti-satellite weapons and will likely have them in their arsenal within the next few years[60, 61]. Additionally, many ground-based satellite-jamming systems have been developed and fielded, such as Krasukha-4 (RUS, against SAR[62] sensors), R-330ZH ZITHEL (RUS, jammer against PNT) and Peresvet (RUS, laser dazzler against electro-optical ISR).[63] Responding to these anti-satellite weapons and satellite-jamming systems, NATO nations are focusing on creating a more resilient constellation[64]. In the distant future, it's imaginable that these effects, especially space-based ISR support, could be requested directly by the JTAC to provide unprecedented levels of space support to ground units, especially in situations where aircraft assets are unavailable or denied access.

5.8 Cyberspace

While the development of the cyberspace domain of operations is 'strikingly similar' to the early stages of development of the air domain[65] and its advancement has been rapid, it is still a highly secretive and relatively new domain. There exist few examples in open sources of how effects through cyberspace operations have been successfully employed due to these operations being held at very high levels of classification. However, in 2007, cyberspace operations were credited with degrading Syrian IADS during an Israeli air strike at a heavily defended area near Deir Ezzor, Syria. The resulting degradation of the Syrian IADS was effective and with enough duration as to allow Israeli aircraft to fly in and out of the highly defended airspace without being engaged by Syrian defences. Though not officially acknowledged, it is widely believed to have been accomplished by a combination of airborne electronic warfare and computer access to communications links between the sensors and the weapons systems of the IADS, while permitting the cyber intruders to observe and manipulate the IADS information displayed.[66]

Since IADS effects have been shown in the past, it's logical that air defence systems will continue to be targets for cyberspace operations, as proposed in a recent JAPCC White Paper.[67] However, because of the often-limited duration that cyberspace operations are able to maintain their effects, and the long lead-times required to design cyberspace operations, regular use of cyberspace in the close support mission is likely a decade or more away[68,69]. CJS cyberspace operations will require a high degree of understanding and pre-coordination being accomplished by the JTAC, ground commander, and likely higher echelon commanders. The establishment of Cyber LNOs for planning and executing Air Operations within the Combined Air Operations Centres is currently being adopted and may eventually play a key role in the planning and coordination of cyberspace CJS operations.

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Part III

Achieving Close Joint Support in NATO

CHAPTER 6

Achieving Close Joint Support in NATO

Part I, including Annex A of this report described the historical use of close support and provided predictions on potential future close support requirements. Part II discussed the many assets that should be available to meet these future requirements, describing the details of the equipment and systems that will need to be in place in order to conduct close support in a wide range of future environments. Here in Part III, we will provide details and recommendations on how NATO should begin to evolve in order to meet these future close support demands by utilizing CJS. We'll begin this section with how best to mould and create the CJS warfighter, equipment, and command and control systems.

To reap the benefits of utilizing systems across the joint and international spectrum to provide close support of ground forces, there will need to be substantial effort and organizational changes made throughout the Alliances' military forces and structural changes inside of NATO. The best foundation for NATO's current ability to conduct CAS, and future ability to conduct CJS, is built by contributing nations obtaining adequate numbers of highly trained personnel, both in the joint and international environments, equipped with the most effective weapons and communications systems available.

Annex B has been created to provide some ideas concerning how the future CJS organizational structure may look like, including changes from today's CAS structure.

The challenges associated with the manning, training, and equipping of NATO's close support cadre is discussed next.

6.1 Personnel

In order to consider if NATO has enough qualified personnel to conduct close support at the tactical level in various scenarios, one must first consider the actual number of qualified ground controllers (JTACs or FACs), airborne controllers (FAC(A)s), and CJS qualified weapons systems operators (fixed-wing and rotary-wing aircrew, artillery, naval gunfire, etc …) within the nations. A full listing of each nations' ambitions and their current inventory, attrition rates, and capacity to train replacement personnel is beyond the scope of this report. However, it is not a stretch to state that the process to create fully qualified JTACs under the current state of the Alliance's CAS doctrine is lengthy and costly, and many nations do not currently possess the number of qualified personnel they desire. This shortfall could become even larger as the Alliance transitions to CJS. The length and cost of future CJS training tracks will be addressed in subsequent paragraphs, however national focus should remain on keeping their 'close support' experienced armed forces. The Alliance will surely benefit from retaining these personnel and employing them as schoolhouse instructors and mentors. They will undoubtedly be a key element in advancing the capacity and capability of close support as new assets are incorporated and tactics developed. Finally, consideration should be given to developing a NATO database that includes all NATO accredited JTACs, FACs, FAC(A)s, and future CJS weapon systems operators. Assuming this database is kept current, it would provide a very clear picture on the Alliance's actual ability to conduct 'close support', and would be invaluable data to help NATO leaders posture the Alliance to be prepared for a peer conflict.

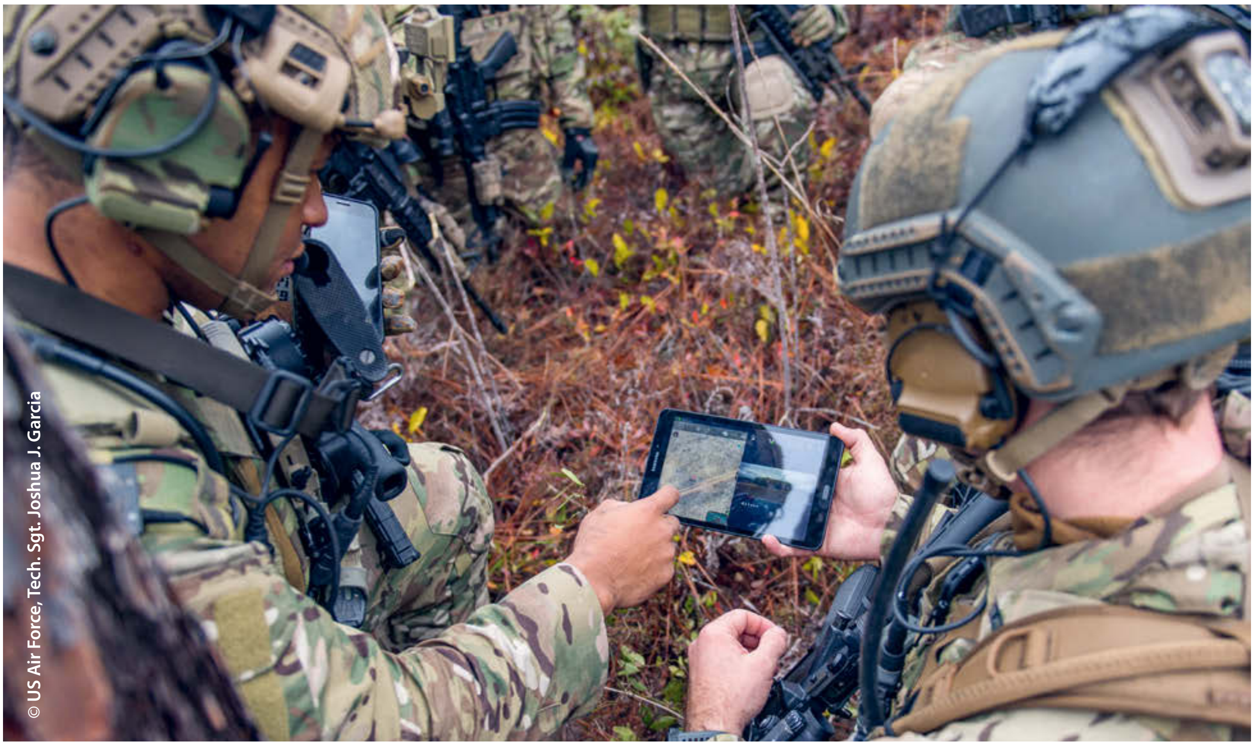
6.2 Training

Before discussing CJS training considerations, it's important to realize that the discussion that follows won't be possible until CJS systems and procedures are flushed out by individual nations within NATO, or within a small group of nations. There is steady effort to this end across many NATO countries, with tangible results likely within 5–10 years. Some considerations could be acted on immediately, while many will need to wait to see what the future of joint effects will look like. As these programs continue to take shape, this list should be referenced when making CJS a reality.

Developing the Command Structure. Many nations across the Alliance are deeply involved in leadership debates at the joint level on how to ensure the individual services are able to coordinate effects. Many leaders feel developing the technology to enable true joint effects isn't the hard part, it's determining who has authority to approve actions and task assets[1]. In addition to the proper C2 framework, joint interoperability standards must be agreed upon and quickly incorporated into acquisition programs across the joint and international services. Concepts such as the USAF's Advanced Battle Management System (ABMS) may have promise[2], but national joint services need to agree upon the basic command concepts which will then lead to the technical and system-specific architecture standards.

Developing the Mindset. A multi-domain, joint approach to tactical and operational dilemmas must be inculcated into the curriculums of schools and training centres. Current trending concepts such as Enhanced Joint Operations (EJO), Multi-Domain Operations (MDO), and Joint All-Domain Command and Control (JADC2) are examples of the joint thinking that needs to be taught and exercised. The desired output from these joint schools is the creation of close support personnel whose tactical acumen has not been stunted by antiquated service-specific thought processes and stovepipes. These 'joint-ready' operators will be the leaders who push the Alliance forward as it strives to dramatically improve close support capabilities and capacities in a peer fight.

Exercising the Concepts and TTPs. Tactical level CJS training needs to be robust. Considering the difficult challenges associated with the logistics, operational tempo, and cost of joint assets conducting CJS training, Live Virtual Constructive (LVC) training will surely be required. Networked, joint facilities are already being utilized by some nations[3], and their



The 6th Special Operations Squadron using the Advanced Battle Management System.

capabilities and joint effects simulations will need to continue to expand in order for provide Alliance-wide realistic CJS training. The optimum solution may be a group of networked, multinational LVC centres able to conduct complex and contested scenarios. Utilizing all the assets available in the scenario (live, virtual, and constructive), the command and control personnel, JTACs, and system operators can be trained simultaneously calling for CJS via assets from any of the LVC hubs.

Updating the Publications. As the procedures and standards for CJS are agreed upon, the publications will need to be updated in a timely manner. The documents need to establish and maintain an agreed upon 'common language'. They should ensure that the symbols, phrases, and communication brevity terms used must be described in such a manner as to eliminate misunderstanding by personnel across the Alliance. This is especially important as NATO transitions to CJS since this transition will involve doctrinal changes throughout the joint spectrum.

Operational-Level Leadership Progress. Training and concept development leading to proper asset allocation must also occur at the operational level. One avenue for this training is through joint, operational level, NATO-led computer-aided exercises. If the scenarios are properly scripted, these exercises are an ideal place to war-game how CJS can help operational commanders solve dilemmas that occur as a result of limited NATO assets while in a peer conflict. The scenarios need to be tailored to truly challenge the training audience while dulling leadership's sensitivity to viewing tactical losses as failures rather than avenues to accomplish learning and concept development. Perhaps most importantly, operational and tactical commanders need to learn and understand how their actions shape other domains and vice versa.

Senior Leadership Development. Lastly, in order to help the transition to CJS occur smoothly with proper funding and understanding at high leadership levels, senior military members need to emphasize educating leaders at the strategic and political levels on CJS concepts and its importance in many future conflict scenarios.

6.3 Equipment

Referencing Part II of this report, details about anticipated and desired future changes to equipment across the joint spectrum has been given. These systems need to be interoperable and networked so they can be effective in providing CJS. And based on the possible scenarios and limited resources of the Alliance, it is critically important that NATO is able to utilize every feasible asset to deliver 'close support' effects. To help tackle the problem of interoperability and networked systems, the use of 'gateways' is essential in that they are able to connect disparate systems, that have very different architecture, into one database or link. One way to ensure proper interoperability and networking of new systems is for nations to coordinate and adopt a minimum level of connectivity for all new systems during their national procurement processes. NATO leadership should support this idea by emphasizing clear interoperability standards for NATO nations to meet with all future national acquisitions that have the potential for use inside the Alliance. Although this seems obvious, due to national budget constraints and competing priorities, many NATO nations are currently unable to meet relatively small interoperability requirements.

Another common trend in the close support mission has been the slow and/or inconsistent ability of new technology to be fully incorporated into the close support community. DACAS is a good example of this. Despite the huge potential for DACAS to create systemic improvements, the development and proliferation of DACAS over the last 15 years has done very little to improve overall close support efficiency. By contrast, other technology improvements have dramatically increased close support efficiency and effectiveness, such as the ability to downlink targeting pod video from close support aircraft to ground controllers. The best chance of acquiring and proliferating effective technology for the close support mission is to involve close support SMEs during every step of the technology development. Additionally, educating the close support community to the potential of these technologies at an early stage in their professional development could reduce the scepticism of the technological advancement, leading to higher implementation rates.

6.4 Command and Control

Currently, most NATO air forces, navies, and armies operate dedicated but independent C2 systems. Sometimes, even the different branches of a nation's army use individual C2 systems, tailored to their specific needs and specialities. These systems often do not communicate with each other seamlessly. However, many NATO nations have identified this issue and are in the process of developing more modern, overarching networks, aiming to bring the different services under a unified C2 architecture. The United States' Joint Automated Deep Operations Coordination System (JADOCS) is an old example of such an approach. The newest and most ambitious architecture to date is the United States Air Forces' Advanced Battle Management System (ABMS)[4]. Developing this type of C2 smart C2 network is one of the keys to reaching CJS goals. The CJS capability inside of this all-domain, joint C2 system would just be a subset of the system's capabilities.

Assets in the AOR will 'check-in' (via a gateway, if required) to the C2 system and provide all the information required for their potential missions. For assets that have CJS capabilities, a minimum list of attributes that they would report are asset type, location, mission status, available time-on-station, specific capabilities and systems onboard, and current payload. The C2 system will consolidate all available assets, along with pertinent available sensor information. This advanced C2 network will need to utilize machine learning and artificial intelligence in order to fully optimize information sharing among the linked nodes (assets and users). Through a robust database characterizing CJS effectors and software able to perform a wide range of real-time calculations (such as

each effectors' approximate time-on-target along with delivery platform/weapon-specific CEPs) and should provide initial CDE based on the target and the actual combat environment[5]. This data will be presented to the personnel who are calling for the effect (JTAC, FAC, FAC(A), or AO) via a prioritized list of potential effectors. Utilizing this type of robust system would provide the CJS terminal controller the best informed choice to select the appropriate ordnance for the current situation.

The amount of detailed information needed to be input into the system would depend on the time available and the level of potential collateral damage. The current Joint Targeting System, developed by NATO Communication and Information Agency (NCIA), could be a good starting point for how to design the close support request, as it includes many of the applicable considerations such as target type, target environment, and BDA assessments[6]. Once the CJS request is submitted, the prioritized list of potential weapons would be provided to the terminal controller. Once the terminal controller selects a weapon from the list, the C2 system will automatically assign the asset and initiate the communication link between the terminal controller and the CJS asset. At least in the beginning, there will need to be a team monitoring this process for many reasons, not the least of which to assign priorities when there are competing requests.

In order for this 'all-domain' C2 system to function properly, a Standardization Agreement (STANAG) of common message sets and reporting formats across all domains and services has to be established. For a seamless integration of a Close Joint Support capability, these STANAGs need to be agreed upon in order for individual systems to provide all required information.

Finally, relevant data and information needs to be presented to the respective users according to their role in the joint fires support process. Many digital systems tend to provide too much information due to the sheer amount of available data, so the design of the human-machine interface should reflect the high workload and potential elevated stress anticipated during close support situations.

6.5 Dynamic Airspace Synchronization

Manually de-conflicting airspace users and trajectories of long-range fires is a complex and often lengthy process. A future robust network tracking all friendly asset positions and trajectories in real-time will create a battlespace where DyAS is possible. The idea of DyAS (as previously described in Chapter 4.3.3) is that instead of allocating airspace by assigning assets to large corridors or blocks, airspace is allocated with scalpel-like precision, allowing for many more users in more closely positioned sections. One of the main advantages of achieving this type of advanced airspace control is that airspace has the potential to be shared safely with aircraft and projectiles operating in spatially closer positions than through the use of today's airspace control measures. The end result for the troops being supported through CJS is that more types of effects will be available in less time due to the streamlining of airspace control procedures. Temporary corridors through allocated airspace may be opened for brief period of times, to allow for stand-off weaponry to pass through, digitally synchronizing aircraft positions and possible future flight paths with projectiles coming from a full list of CJS assets including those from land, air, sea, below the sea, and space. This type of flexible airspace control measures will be absolutely critical to enabling the ground commander to utilize all available CJS effectors in an efficient manner.

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4. Insinna V., 'The Air Force just conducted the first test of its Advanced Battle Management System', C4ISRNET, 20 Dec. 2019. Available online at: https://www.c4isrnet.com/air/2019/12/21/the-air-force-just-conducted-the-first-test-of-its-advanced-battle-management-system/, accessed 2 Jan. 2020.
5. Processing a CDE requires a large amount of data that may include the distance from the target to adjacent civilian infrastructure, statistical data about population density, pattern of life in the area, weapon delivery profile specifics, programable weapon parameters such as the fuse delay, and environmental factors such as current GPS availability and accuracy along with atmospheric conditions. The anticipated C2 system would have this data available to process the CDE factor.
6. Zinca, Diana-Ioana. 'Joint Targeting System – The Support Tool for Joint Targeting Cycle and it's Applicability in Computer Assisted Exercises', Bulletin of National Defense University, Jun. 2018. Available online at: file:///Users/dkmzop/Downloads/507-2324-1-PB.pdf, accessed 28 Nov. 2019.

An F-35 conducts flight test of the JSOW C-1 net-enabled missile.

CHAPTER 7

Conclusion

This report has argued that over the past three decades, NATO air operations were conducted in primarily unopposed airspace and, due to high available asset density, CAS has been continuously provided. Close support TTPs have evolved to support efficient operations in this permissive and asset-dense environment. However, improvements in the capabilities of potential adversaries, combined with reductions in Allied assets, have created future scenarios where these high standards of available close support would be greatly challenged.

Through analysing the last 100 years of close support operations, this report has concluded that there are four main factors to consider when holistically evaluating the effectiveness of close support. These factors are the level of achievable integration with the supported unit, the accuracy of the provided effects, the accessibility of the airspace near the supported unit, and the timeliness that the effects can be delivered. When considering future conflict scenarios against potential peer adversaries, the possibility that ground units will need close support in contested environments is high. This report also purposes that the Alliance's current air assets may be too few (or not capable enough) to fill the large requirement on our air forces to conduct sorties spanning the entirety of potential air missions (close support being just one). In order to increase the amount of available close support effects to ground units, an entirely joint approach to delivering effects is suggested.

The legacy term, 'Close Air Support', is exclusionary in that it puts heavy emphasis on air-delivered effects, and therefore necessitates replacement. This report suggests the adoption of the term 'Close Joint Support' as an alternative, arguing that CJS maintains emphasis on the unique requirements that 'close support' demands, while placing importance on the effects coming from assets from all available services (and domains).

Worldwide, rapid technological advancements in military systems are enabling now, and in the near future, a sudden expansion of weapons able to provide effects in scenarios where high levels of integration are needed to meet the timeliness and collateral damage requirements of close support. These joint weapons include everything from long-range, network-enabled missiles fired from ships in blue water to overhead, long-endurance UAVs with on-board payloads able to be directly controlled by ground units.

In order for these new weapons to be utilized in close support situations, changes must occur across all Allied nations and within the Alliance itself. The proper number of joint trained personnel (including terminal controllers, joint C2, and CJS asset operators) must be determined, produced, and sustained. Standards for interoperability between current and next-generation equipment, along with national policies allowing the systems to interact and share information need to be established. Adaptations in areas such as Joint Fire Support Team construct, joint C2, and airspace control measures will also need to be made. Substantial modifications to current command structures, asset allocation and control, along with interoperability are already being deliberated by many of NATO's leading nations. Modifications within our militaries and across NATO leading to improved joint cohesion and interoperability is absolutely paramount for the Alliance to be able to meet the close support demands of the future.

NATO's charge is to prepare today for the most challenging future scenarios. This report has attempted to make the case that the Alliance's current pace of advancement in close support technology and capability may not be properly preparing us for these battles. As shown throughout history, when our forces are competent in conducting joint operations, such as close support, we are exponentially more successful and survivable. The effectiveness of close support has the potential to change the outcome of the war, let alone increase the survivability of individual units and soldiers. With this in mind, we need to make the difficult changes now. We must eliminate our service-specific ways of thinking while altogether supporting joint solutions in order to produce an Alliance able to provide persistent close support for our ground forces operating anywhere around the world.

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World War II (1939–1945).

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Desert Storm (1991).

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Somalia (1993).

ANNEX A

A Brief Look into the History of Close Air Support

This Annex focuses on how the Air Component has conducted close air support, beginning with the First World War. Each major conflict brings about changes in CAS organization, equipment, doctrine, and training. Succinctly reviewing the evolution of CAS and lessons learned over the last approximately 100 years will help set the stage to analyse how emerging technology and challenging warfighting environments may require CAS concepts to continue to evolve in order to effectively support ground forces in the future.

Periods of Conflict

World War I

Just over a decade after the Wright brothers accomplished their first powered flight, World War I (WWI) began. In November 1913, despite developed doctrine, the first air support of ground troops was conducted by Spanish aircraft in North Africa. Concurrently, the first air-to-ground weapons used were German-made, hand-held bombs of about 10 kg. The value of this new type of fire support was immediately recognized, both in terms of psychological and physical effects on the enemy. The first CAS doctrine was created by the Allies in 1916. The 1917 battle of Cambrai, was the first battle which featured air support in the battle plan on a large-scale.[1] During this

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Korean War (1950–1953).

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Vietnam War (1955–1975).

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Afghanistan (2001–Present).

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Operation Inherent Resolve, Iraq (2017).

battle, British attacks of enemy troops in trenches close to friendly forces was the first occurrence of modern-day CAS. Although CAS was shown to be effective towards the end of the war, its overall usefulness was largely hampered by a lack of two-way communication between the aircraft and the friendly ground forces requesting the support.[2]

World War II

The Allies did little development of CAS doctrine and TTPs between the world wars. Germany, on the other hand, realized the potential effectiveness of combining highly mobile forces with air assets. The air assets provided support similar to traditional fixed artillery, but were highly mobile and could keep up with the rapidly advancing German tanks. Notably, as early as 1938 Germany had completed the design and manufacture of a complete line of portable radio equipment[3] for its army and air force, thereby providing the first reliable means of close coordination between ground forces and air assets.

Due to other priorities, the US Army and its Air Force entered World War II (WWII) without effective CAS doctrine. When the Allied Commander in North Africa, General Eisenhower, recognized the overall ineffectiveness of his air forces' integration with army troops, he requested combined CAS training for all forces being sent to Africa, which eventually led to the development of improved Allied CAS doctrine.[4] As WWII progressed, CAS operations in Italy led to the creation of many of the techniques that the allies used in the invasion of Normandy and in the subsequent fighting through France and Germany[5]. Two substantial procedural CAS developments occurred during this time. The regular use of Aircraft Control Parties (ACP) and Aerial Forward Controllers (AFAC) began. ACPs were Air Corps specialists that consisted of a pilot and Infantry or Armour men with maps, aerial photographs and radios. They communicated with ground units as well as aircraft and were integrated into Army units to plan, request, and direct air strikes in close proximity to friendly forces. AFACs were pilots who integrated with Army units to provide control of CAS assets (similar to today's FAC(A)'s). The addition of these air specialists to army units provided significantly increased synergy between the air and ground assets, and were essential to Allied success. The time it took from air support being requested to having an aircraft on station went down as assets were allocated for 'prearranged' CAS requests 24 hours in advance. With the introduction of these 'on-call' or 'air-alert' CAS aircraft being stationed over the front lines; response time went down to as low as five to ten minutes[6]. As air superiority was increasingly achieved, CAS became more and more used in support of the advance in Europe.

Korea

The approved USAF-US Army CAS doctrine at the beginning of the Korean War (Field Manual 31–35, *Air-Ground Operations,* published August 1946) had its origins from techniques discovered in North Africa and continued to be refined and modified throughout the battles in Italy and the rest of Europe during WWII. The field manual also incorporated TTPs used during the WWII Pacific Island-hopping campaign by USMC and USN forces. However, although the doctrine existed, forces on the ground and in the air were not proficient in CAS at the start of the war. CAS training and numbers of qualified aircrews were both insufficient. In fact, the USAF Far East Air Force (FEAF) had only one TACP squadron, and it had not adequately trained with the fast jet aircraft subsequently used in Korea[7].

Despite this, the FEAF rapidly learned from their early mistakes and quickly became crucial to ground force successes. During August and September of 1950, while the US Eighth Army was greatly outnumbered by North Korean forces in the perimeter of Pusan, unprecedented CAS support kept the North Korean divisions pinned down, unable to mass their forces. With American air superiority established, the FEAF flew 7,397 CAS sorties during August alone, averaging 238 sorties per day.

In an excellent example of the flexibility of airpower, when centrally controlled and allocated, FEAF assets used air interdiction and CAS missions to counter North Korean advancements against which ground forces were not in position to immediately repel[8]. Generous allocation of CAS was also given to offset the lack of organic artillery. 'In Korea, we have only 25 percent the number of guns we had per division in France', General Van Fleet, Commander 8th US Army and UN Forces Korea, stated in April of 1953[9].

Also, FAC(A)'s were pivotal to the success of many battles in Korea, including the Inchon landing. The 'Mosquito' FAC(A)s of the 6147th Tactical Air Control Group began carrying radios in their cockpits, allowing them to talk directly with tank columns and forward ground patrols. They maintained positions on the front and flanks of advancing ground forces and directed CAS assets to attack North Korean tanks and infantry attempting to counter the advance[10]. This support proved vital to the success of the Inchon assault.

Vietnam

The war in Vietnam was different in that there was essentially a lack of a defined front. Ground units contacted the enemy in pockets over a wide area, the rear area was less defined with fewer strategic targets, leaving CAS, especially air support for 'search and destroy' missions, as a substantial part of the air effort[11]. CAS support also became available 24 hours a day. The increase in CAS availability was in large part due to improvements in the capability and the reliability of the aircrafts' systems such as navigational aids, Infrared (IR) targeting pods, and Electronic Countermeasures (ECM). Aircraft were now more effective at night and in inclement weather than in previous conflicts. Additionally, a more sophisticated Air Command

and Control (Air C2) process was developed in 1962 (and approved in 1965) which designated the Tactical Air Control Center (TACC) as the tactical air forces' operational facility that planned and coordinated CAS employment. Direct Air Support Centres (DASCs) were subordinate to the TACC, with their prime function to provide fast reaction for immediate close air support and tactical air reconnaissance. Tactical Air Control Parties (TACPs) forwarded requests for immediate air support to the DASC who had CAS assets at their disposal and assigned them tasking, as appropriate.[12] This streamlined construct made CAS much more efficient, with ground alert aircraft taking on average 35 to 40 minutes to put ordnance on targets while diverted aircraft required 15 to 20 minutes[13, 14].

Additionally, FAC(A)s were reintroduced due to the terrain and vegetation[15], providing effective strike aircraft control and final release authority of ordnance in close proximity to the ground forces. Due to their ability to monitor the battlefield from the air, FAC(A)'s often had increased situational awareness and were able to more quickly and accurately direct CAS assets to the proper target, especially while troops were in contact[16].

'Gunships' such as the AC-47, and later the AC-130, were specifically developed for CAS and equipped with significant ordnance, firepower, and loiter time. By 1968, the first Laser-Guided Bombs (LGB) were introduced, dramatically improving bomb accuracy. Although the majority of the over 10,000 LGBs delivered in Vietnam were expended during interdiction missions, the new precision greatly reduced collateral damage estimates making it possible to strike targets much closer to civilian centres and friendly troops[17].

With much-improved system capability, reliability, precision, and 24-hour on-call CAS assets available, the ground forces quickly became reliant on air support, favouring it over their own organic support. Despite the many successes of CAS in Vietnam, there were those who saw danger, parochial or not, in an assumption of perpetual air support. After the war, US Army General Theodore R. Milton commented, 'The Army became over-dependent on-air support, and air support of a kind highly vulnerable against a modern force'.[18] Considering this statement in today's situation, there is an interesting parallel between NATO's current focus and the post-Vietnam period where it had become accustomed to fighting an asymmetric war, and then was forced to return focus towards a peer adversary.

The Late Cold War Years (1972–1991)

Over these two decades the Alliance prepared to defend itself against the former Soviet Union. NATO postured for a large conventional war against a well-armed enemy. For the first time, CAS doctrine and TTPs were practised, refined, and updated with emerging technology. As the Alliance's Electromagnetic Operations (EMO) capability increased throughout this period, Electronic Attack and Suppression of Enemy Air Defence (SEAD) was included in CAS training and doctrine[19]. Additionally, the USAF produced the extremely capable A-10 'Warthog' and the US Army acquired new attack helicopters. With the break-up of the Soviet Union and the end of the Cold War in 1991, NATO countries re-structured their armed forces for smaller-scale conflicts and reduced their defence expenditures. During this transformation period, several conflicts took place and continued to shape CAS execution.

Yom Kippur War (1973)

The Arab-Israeli War in October 1973 is an interesting case of 'western' tactical aircraft conducting CAS and air interdiction missions against an adversary operating Soviet Union supplied surface-to-air missile systems. The Israeli fighter-jets did not possess self-protection systems which were properly configured to detect and counter the Egyptian integrated air defence radars and mobile SAM units. As the Syrian and Egyptian forces marched closer to Israel's capital, Israel's air forces were required to conduct missions in contested 'high-risk' environments. The result was a staggering Israel attrition rate, with 34 fighters shot down in the first four days[20]. By the end of this short, 3-week war, 115 Israeli aircraft were lost, 100 of them shot down by surface-to-air fires[21]. Israeli tactics, along with aircraft systems, were not adequate to maintain acceptable survivability when operating in a contested environment, which led to an attrition rate that would not be sustainable for most air forces in today's Alliance.

Desert Storm (1991)

Although the lack of resolute Iraqi resistance caused only a few occurrences of CAS during the ground offensive, it played a pivotal role for the US Marines[22]. Being an expeditionary, amphibious, light infantry force, they lacked the organic fire support that Army forces normally possess. Thus, the speed, mobility, and firepower of CAS was especially important.

The Iraq war showed how combining a joint force of air assets, trained in the joint environment, could capitalize on the strengths of different platforms to achieve an overwhelming effect. In the Battle of Khafji, AV-8s, F/A-18s, A-6s, AH-1Ws, A-10s, and AC-130s were used simultaneously, pushing back the Iraqi advance. CAS, along with coordinated Marine artillery and naval gunfire, were the key to defeating Iraqi forces in their last offensive operation in the war[23].

Notable CAS advancements occurred in the use of Night Vision Goggles (NVGs) and a much higher percentage use of Precision-Guided Munitions (PGM).

Somalia (1993)

United Nations Operation in Somalia II (UNISOM II) brought CAS to a truly urban environment. In October of 1993, two US MH-60 Black Hawks were downed inside of the city of Mogadishu. The resultant CAS operations highlighted the challenges of operating in an urban environment. The difficult problems of collateral damage, proportionality, and enemy identification and tracking were amplified during this CAS event[24]. The events in Somalia identified that current CAS doctrine needed to be matured for the urban environment. Additionally, effective air support for Special Operations Forces (SOF) was a critical capability and training between CAS aircrew and SOF needed more emphasis[25].

Iraq War (2003)

During the conventional, asymmetric war fought in March–April 2003, the vast majority of strike sorties, over 75 %, were dedicated to support ground forces which had essentially 24-hour CAS support as they quickly pushed back the Iraqi forces[26]. Additionally, PGMs accounted for the majority of the weapons employed, the vast majority of which were LGBs and GPS-guided Joint Direct Attack Munition (JDAM). There were few interoperability issues between units as the number of nations in the coalition was relatively small and mostly English speaking. Without a credible Iraqi air defence, the coalition once again enjoyed air superiority and had assets in theatre to provide robust and constant CAS to ground forces.

Counterinsurgency (2001–Present)

Counterinsurgency (COIN) operations in Iraq, Afghanistan, and Syria have required a large quantity of CAS. In 2016, General Welch, a previous USAF Chief of Staff stated the USAF flew on average twenty thousand CAS sorties a year from 2008–2015[27]. Without readily available strategic and rear area targets, ground forces have become accustomed to receiving the lion's share of air assets, which have had the luxury of complete air supremacy and unmolested use of airspace. Without the threat of credible surface to air fires or enemy counter-air aircraft, CAS TTPs have been adjusted to this permissive environment. High-threat CAS experience, and in many cases training, has been almost completely removed from the Alliance's training paradigm.

Technology rapidly improved during these years, enabling aircraft to strike targets with more accuracy and with less collateral damage. Dual-mode precision-guided munitions, utilizing precision GPS along with laser terminal guidance, have enabled very accurate strikes even within urban and obscured conditions. Newly introduced Small Diameter Bombs (SDB) have been effective at destroying targets even when collateral damage requirements are extremely restrictive. Live video feed from the aircraft can be sent directly to JTACs, enabling much quicker (and more accurate) target identification, leading to a reduction in time to engage. During recent operations in both Iraq and Syria, US JTAC's have been able to control aircraft performing CAS far from the coordinated fires[28]. Additionally, Unmanned Aircraft (UA) such as the MQ-9, have become extremely effective CAS assets, employing weapons while also able to identify and track targets for extended periods of time[29]. With the Alliance largely focused on COIN operations, these technological advances have been directly applied to benefit operations in this environment.

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Field Artillery Soldiers using the Joint Effects Targeting System Target Laser Designation System (JETS-TLDS).

ANNEX B

Close Joint Support Organizational Structure

In an effort to initiate creativity and critical thinking inside existing CAS subject matter expert groups, this annex is provided to describe a possibility for future CJS organizational structure.

Joint Fire Support Teams

As the commanders of future NATO ground forces are able to access effects from all possible CJS assets, the distinction between ground-to-ground controllers and air-to-ground controllers dissolves. The resulting final control would be performed by Joint Fire Support Teams (JFST). The JFST is completely embedded into the ground force's structure with robust C2 links to the ground commander and CJS assets and their associated effectors through the CJS C2 network. Inside of the JFST there may be a range of qualifications determining who can authorize weapons release based primarily on if the anticipated operations are considered 'close support'. If the operations are not determined to be CJS, then the release authority may be handled by personnel with lower qualifications (such as todays Artillery Observer). If the effects are considered 'close support', then the JFAC inside the JFST will need to handle the final control of the delivered effects.

Joint Fire Support Coordination Teams

A highly dynamic, congested, and contested battlefield is very likely to generate a significant number of requests for close support. Accurate prioritization of targets according to the ground commander's intent as well as the timely and effective allotment of available effectors will be essential for accomplishing the mission. An essential pre-requisite in order to provide this coordination would be the establishment of an accurate common operating picture (COP)[1]. Referencing the ground commanders' intent, the COP, and the CJS fires system, the Joint Fire Support Coordination Team (JFSCT) could manage the sequencing of CJS events. As computer systems continue to evolve and become more capable, the JFSCT could monitor this process from outside the loop, in an effort to increase the kill chain and reduce errors.

The sheer amount of diverse weapons systems, ordnance types, and individual weapon parameters of a joint fires force, will require a substantial amount of training to control. Utilizing a highly sophisticated CJS fires system has the potential to reduce the amount of technical information the JFSCT would need to memorize or have available (such as all bomb fuse combinations, bomb body types, effects radii, and applicable asset details, etc …), however, there will still be a need for higher qualified personnel in a coordination role above the unit level, but in significantly lower numbers. The following qualification levels may serve as a reference model:

Joint Fires Observer (JFO)

There may be multiple JFOs embedded into a combat unit and they are part of the JFST. Their main task is to observe the battlefield, identify targets and determine target coordinates. The JFO will also provide advice for the selection of the proper weapon to use to create the desired effect against the target. The JFO has the authority to request, but not to release, joint fires by feeding target information into the respective Joint Fires C2 system. The JFO's envisioned qualification is comparable to current Artillery Observers, however, lacking the authority to directly control and release fires.

Joint Fires Controller (JFC)

The JFC is in charge of the JFST and commands the JFOs. The JFC is the unit commander's direct advisor for joint fire support and responsible for coordinating own fires with the movement of the troops on the ground. Therefore, the JFC is the only release authority for any joint fires in the unit's area of responsibility. In addition to the JFO qualification, the JFC's envisioned training encompasses the ability to determine weapon effects for preventing collateral damage and fratricide, and, consequently, the authority to control and release fires. The JFCs may also be trained in back-up control of assets via methods like voice radio, similar to the way JTACs provide terminal control for aircraft using todays CAS procedures.

Joint Fires Support Coordinator (JFSC)

One or more JFSCs form the Joint Fire Support Coordination Teams above the unit level. They coordinate the seamless integration of all available weapon systems and prioritize their allocation according to the supported commander's intent. They also ensure the spatial and timely de-confliction of fires and friendly airspace users. JFSCs are envisioned as experienced JFCs with additional cross-service qualifications in the area of Fire Support Coordination Measures and Airspace Control.

1. Establishing a COP is not an easy task with today's systems as current national and service-specific C2 systems have difficulties maintaining reliable compatibility and connectivity.

ANNEX C

Acronyms and Abbreviations

A2/AD	Anti-Access Area Denial
AAR	Air-to-Air Refuelling
ABMS	Advanced Battle Management System
ACO	Airspace Control Order
ACP	Aircraft Control Parties
ACT	Allied Command Transformation
AFAC	Aerial Forward Controllers
AFRL	Air Force Research Laboratory
AI	Air Interdiction
AIRCOM	Allied Air Command
ALSA	Air Land Sea Application Centre
AO	Artillery Observer
AOR	Area of Responsibility
ARM	Anti-Radiation Missile
C2	Command & Control
C4ISR	Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance
CAOC	Combined Air Operations Centre
CAS	Close Air Support
CATOBAR	Catapult Assisted Take-off Barrier Arrested Recovery
CCA	Close Combat Attack
CDE	Collateral Damage Estimate
CEP	Circular Error Probable
CJS	Close Joint Support
COIN	Counterinsurgency
COTS	Commercial-Off-The-Shelf
CTOL	Conventional Take-off and Land
DACAS	Digitally-Aided Close Air Support
DASC	Direct Air Support Centre
DEW	Directed Energy Weapon
DyAS	Dynamic Airspace Synchronisation
EA	Electronic Attack
EAG	European Air Group
ECM	Electronic Countermeasures
EM	Electromagnetic
EMO	Electromagnetic Operations
EMP	Electromagnetic Pulse
EMRG	Electromagnetic Rail Gun
EPLRS	Enhanced Position Location Reporting System
EU	European Union
EW	Electronic Warfare

FAC	Forward Air Controller
FAC(A)	Forward Air Controller (Airborne)
FEAF	Far East Air Force
FMV	Full Motion Video
GEO	Geosynchronous
GPS	Global Positioning System
HEL	High Energy Laser
HOS/G	Heads of State and Government
HPM	High-Power Microwaves
HVP	Hypervelocity Projectile
IADS	Integrated Air Defence System
ISR	Intelligence, Surveillance, and Reconnaissance
JADOCS	Joint Automated Deep Operations Coordination System
JAPCC	Joint Air Power Competence Centre
JDAM	Joint Direct Attack Munition
JFC	Joint Fires Controller
JFO	Joint Fires Observer
JFSC	Joint Fires Support Coordinator
JFST	Joint Fire Support Team
JSOW	Joint Standoff Weapon
JTAC	Joint Terminal Attack Controller
IR	Infrared
ITA	Integrated Tactical Network
LAA	Light Attack Aircraft
LEO	Low Earth Orbit
LGB	Laser-Guided Bomb
LNO	Liaison Officer
LoAC	Law of Armed Conflict
LOS	Line of Sight
LRLAP	Long-Range Land-Attack Projectile
LSC	Large Surface Combatant
MANPAD	Man-Portable Air-Defence System
MDC2S	Multi-Domain Command and Control System
MIDS	Multifunctional Information Distribution System
MLRS	Multiple Launch Rocket System
MOC	Maritime Operations Centre
MTB	Midrise or Taller Building
MUM-T	Manned-Unmanned Teaming
NATO	North Atlantic Treaty Organization
NSFS	Naval Surface Fire Support
NVG	Night Vision Goggles
PGM	Precision-Guided Weapon
PNT	Position, Navigation and Timing
PRS	Public Related Service

RAND	Research and Development
ROZ	Restricted Operating Zone
RPG	Rocket-Propelled Grenade
RW	Rotary-Wing
SADL	Situational Awareness Data Link
SAM	Surface-to-Air Missile
SATCOM	Satellite Communication
SDB	Small Diameter Bombs
SEAD	Suppression of Enemy Air Defence
SFA	Strategic Foresight Analysis
SOF	Special Operations Forces
STANAG	Standardization Agreement
STOVL	Short Take-off Vertical Land
TAC	Terminal Attack Control
TACC	Tactical Air Control Centre
TACP	Tactical Air Control Parties
TDL	Tactical Data Link
TTP	Tactics, Techniques, and Procedures
UA	Unmanned Aircraft
UAS	Unmanned Aerial/Aircraft System
UAV	Unmanned Air Vehicle
UN	United Nations
UNISOM II	United Nations Operation in Somalia II
USA	United States of America
USD	United States Dollar
USAF	United States Air Force
USMC	United States Marine Corps
USN	United States Navy
UXO	Unexploded Ordnance
VMF	Variable Message Format
WWI	World War I
WWII	World War II

Daniel D. Cochran
Commander (USA N), NATO OF-4
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ANNEX D

About the Authors

Commander Daniel D. Cochran, USA Navy

Commander Cochran joined the United States Navy in 1998 upon completion of a Bachelor's degree in Materials Science and Engineering at Rensselaer Polytechnic Institute in Troy, New York. He was designated a United States Naval Aviator in April, 2001.

His subject matter expertise is in aircraft carrier operations, strike-fighter employment, and fighter integration.

Commander Cochran has completed three operational tours while assigned to F/A-18C and F/A18E squadrons. He's enjoyed 14 operational deployments on four different aircraft carriers projecting power and conducting combat missions in support of Operations SOUTHERN WATCH, IRAQI FREEDOM, ENDURING FREEDOM, and NEW DAWN. In 2016 he assumed command of Strike Fighter Squadron TWO SEVEN (VFA-27) employing the F/A-18E 'Super Hornet' forward-based in Atsugi, Japan. He led his command through three deployments and six international and joint exercises strengthening ties with partner nations throughout the Pacific AOR while deployed on the USS RONALD REAGAN (CVN 76) attached to Carrier Air Wing FIVE (CVW-5). Successfully completing his command tour, he reported to the JAPCC in October 2017.

Commander Cochran is a distinguished graduate from the Air Force Institute of Technology earning a Master's of Science in Aeronautical Engineering. He's a United States Naval Test Pilot School (USNTPS) graduate and has held many test pilot positions including F/A-18A-F and EA-18G air vehicle manager and instructor duty at USNTPS. He's also a member of the Society of Experimental Test Pilots. He's accumulated 3,200 flight hours in 32 aircraft and 760 carrier arrested landings.

Commander Cochran lives in Kleve, Germany, with his wife and four children. His hobbies include sports, woodworking, general construction, and music.

André Haider
Lieutenant Colonel (DEU A), NATO OF-4
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Lieutenant Colonel André Haider, DEU Army

Lieutenant Colonel Haider joined the German Armed Forces in April, 1992. He first served as Personnel NCO in the 150th Rocket Artillery Battalion HQ. In his first assignment after promotion to Lieutenant in 1998 he served as a platoon leader in the 150th Rocket Artillery Battalion. After three years, he was posted at the 150th Rocket Artillery Battalion HQ as the CIS Branch Head.

Thereafter, he was assigned to the 325th Tank Artillery Battalion in Munster as a battery commander. He then served as the commander of the maintenance and supply battery.

In 2008 he was posted at the 284th Signal Battalion in Wesel, again as a commander of a maintenance and supply company. In 2010 he was the Deputy Commander of the German support staff to the 1st NATO Signal Battalion in Wesel. His last assignment was Deputy Battalion Commander of the 132nd Rocket Artillery Battalion in Sondershausen.

In 2004/2005, Lieutenant Colonel Haider was posted at KFOR MNB(SW) as the Officer in Charge of the resettlement of the Serbian refugees after the March 2004 riots in Prizren, Kosovo.

In 2011, Lieutenant Colonel Haider was the Officer in Charge for the rapid deployment of NATO's German Operational Reserve Forces Battalion to Kosovo.

Since 2012 he has been assigned to the JAPCC Combat Air Branch as a Subject Matter Expert for Unmanned Aircraft Systems. He authored White Papers on operations of 'Remotely Piloted Aircraft Systems in Contested Environments', creation of a 'NATO/Multinational Joint Intelligence, Surveillance and Reconnaissance Unit', and 'Legal and Ethical Implications of Increasing Unmanned System Automation'.

Lieutenant Colonel Haider is the JAPCC's representative to the NATO Joint Capability Group Unmanned Aircraft Systems, the NATO Counter-UAS Working Group, and the NATO Maritime Unmanned Systems Steering Board.

Panagiotis Stathopoulos
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Lieutenant Colonel Panagiotis Stathopoulos, GRC Air Force

Lieutenant Colonel Panagiotis Stathopoulos graduated from the Hellenic Air Force (HAF) Academy with a BSc in Aeronautics in 1995. He holds an MSc in Human Factors and Safety Assessment in Aeronautics from Cranfield University, UK in 2008.

He is currently serving as the Electronic Warfare (EW) including SEAD Operations SME at the Joint Air Power Competence Centre.

Lieutenant Colonel Stathopoulos initially flew the F-5A/B Freedom Fighter aircraft, and he is an experienced F-16 instructor and functional check flight (FCF) pilot with over 2,000 hours of pilot in-command time. He is a graduate of the HAF Tactical Weapons Fighter School, whereas has served as a fighter pilot in HAF 347 Fighter Squadron flying Low Altitude Navigation and Targeting Infra-Red Night (LANTIRN) operations and employing precision-guided weapons towards air-to-ground missions. After completing his MSc studies in Human Factors, he also served as staff officer in the Tactical Air Force Safety Division/Proactive Aviation Safety Branch. Besides, he has served as Director of Operations (DO) and as Squadron Commander of HAF 341 Fighter Squadron.

Apart from his considerable experience on Composite Air Operations (COMAO) and EW expertise, Lieutenant Colonel Stathopoulos has also significant experience in air policing operations. In particular, he was the F-16s formation leader, when he executed the assigned operational air policing mission to intercept the potential renegade Boeing 737 of HELIOS Airlines on August 2005, which finally crashed to Grammatiko in Athens, Greece.

In addition, Lieutenant Colonel Stathopoulos has considerable experience in large-scale exercises planning and execution both at national and NATO level, whereas he is a human factors specialist.

He lives in Germany with his wife and twin children.

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