Transforming Joint Air Power
The Journal of the JAPCC

Edition 24, Spring/Summer 2017

Editorial

It is our great pleasure to present the 24th Edition of the JAPCC Journal. A prominent theme permeating this journal is the significance of the Joint Strike Fighter arriving in many NATO Allies' national forces. Starting off, Major General Max A. L. T. Nielsen, the Danish Air Chief, provides us his perspective on the unprecedented potential of the F-35 and the challenge of developing Tactics, Techniques & Procedures to fully exploit its 5th generation capabilities in a system of systems with 4th generation aircraft that will remain widely in service. This is a capability that is going to truly transform the way NATO air power is employed across all domains including space and via cyber.

Another transformational capability is hypersonic flight. Effective, reliable and efficient hypersonic aviation presents amazing opportunities. A comprehensive article from the NATO Science and Technology Office gives a view into the current state of this technology. Following this theme of future capabilities is the first in a series of three articles about future rotorcraft and the operating environment we expect to see for them in 2035. For a comprehensive look into this issue, the JAPCC has established a Rotary Wing Focus Group that includes rotary wing experts from land and maritime forces in addition to Air Force SMEs on Personnel Recovery, Special Operations, Attack and Airlift.

Shifting gears, two articles address cutting-edge training to improve the interoperability and effectiveness of NATO forces. First, the Distributed Training Operations Centre and the growing efficacy of Live-Virtual-Constructive training is a cost-effective solution to keep NATO forces current, qualified, and ready to operate cooperatively in a conflict. Next, JAPCC has developed a new program for training and exercising NATO planners in the coordination of Air-to-Air Refuelling clearances between nations, based on lessons learned in Operation Unified Protector. This is a major step in the development of non-US AAR capacity across NATO, and both of these programs are significant force multipliers for the Alliance.

Returning to our 5th Generation theme, we have European and American perspectives on the advent of 5th generation air combat and the F-35, followed by a JAPCC perspective on the broader question of how 5th generation aircraft will be integrated into the coming networked Command & Control (C2) environment. Two additional viewpoints explore the use of training and technology to improve rotary wing safety in brownout conditions, and the integration of new Maritime Patrol Aircraft capabilities into networked C2 for better Anti-Submarine Warfare and Detection and Monitoring. Wrapping up this issue are a trio of outside the box articles on the growth of Close Air Support as an air force mission area, new threats and considerations for hybrid warfare, and the Competence Centre for Surface-Based Air and Missile Defence.

We thank you for taking the time to read this edition of our Journal, and thank our authors for their insightful contributions to what we hope you find to be an educational and thought-provoking issue. We strongly encourage our readers to share their thoughts as they go forth and advocate for air power, and to contact us at www.japcc.org, like us on Facebook, or follow us on Twitter or LinkedIn to tell us what they think. Good Reading!

Tod D. Wolters
General, USA AF
Director, JAPCC

The Journal of the JAPCC welcomes unsolicited manuscripts.
Please e-mail submissions to: contact@japcc.org

We encourage comments on the articles in order to promote discussion concerning Air and Space Power.

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Table of Contents

Inside the JAPCC

Book Reviews

Imprint:

Transforming Joint Air Power: The Journal of the JAPCC

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Purpose
The JAPCC Journal aims to serve as a forum for the presentation and stimulation of innovative thinking about strategic, operational and tactical aspects of Joint Air and Space Power. These include capability development, concept and doctrine, techniques and procedures, interoperability, exercise and training, force structure and readiness, etc.

[M] **Denotes images digitally manipulated**

Royal Danish Air Force – Next Generation

Interview with Major General Max A. L. T. Nielsen, Chief of Air Staff, Defence Command Denmark

The JAPCC is grateful to Major General Max Nielsen for taking the time to provide us with the Danish perspective on key issues facing the joint Air Power community in the near future.

The world has changed since the Russian annexation of Crimea. In this context, with a resurrected threat in the east, what it your primary focus for the Royal Danish Air Force?

After more than fifteen years of fighting terrorism, we have grown accustomed to being superior to our opponent in regards to our war fighting capabilities. In the near future, we must – once again – be ready to face an advanced and determined peer-level adversary, to ensure that if diplomacy and deterrence fail, we can fight and win our nations' wars. To do this, we must elevate the capabilities of all platforms, by reviewing and rethinking them from a doctrine, organization, and technology perspective. In the Royal Danish Air Force, we believe that integration of the F-35 will increase the capabilities of all platforms, not only those of the Royal Danish Air Force, but also platforms in a joint and combined context. For instance, the F-35 is an excellent platform for gathering intelligence, both imagery and signal intelligence,

The Chief of Air Staff attends the official ceremony for the change of Command at the Expeditionary Air Staff, Air Base Karup.

The first four Danish F-35 will be deployed to Arizona in 2021. In 2022 two more F-35 will be deployed to Arizona, and the first two F-35 will be deployed to Fighter Wing Skrydstrup, Denmark.

thus being able to provide essential information to specific missions or information critical to Electronic Counter Measures on a theater level. In an Anti-Access Area Denial (A2AD) scenario, the F-35 will be able to operate in a hostile A2AD environment, and by suppressing, disrupting or defeating the enemies' A2AD capabilities and networks, it will enable Friendly Forces to operate in the theater. In other words, we do not just see the F-35 as a new and more capable fighter, we also see it as a catalyst for our armed forces, enabling them to be more effective.

In order for us to be ready to face an advanced and determined peer-level adversary, we must revitalize some of the forgotten Cold War virtues and put them into a modern context. For the Royal Danish Air Force this means the necessity to increase our war fighting capabilities, thus our primary focus for the coming years is the successful implementation of the F-35. In this process it is essential that we do not force the F-35 to fit into the Royal Danish Air Force as is, but rather seek to make the combined Danish armed forces fit to benefit from the F-35. Only then will we be able to harness the true potential of this fighter of the future, and thereby hold the ability to prevail should the need arise.

If nations, like Denmark, who procure the F-35 will redesign their armed forces to optimize operations with a 5th generation platform like the F-35, how will this influence combined NATO operations, where many nations won't have 5th generation capabilities and the bulk of forces are predominantly 4th generation?

At this moment, only a handful of NATO countries are destined to procure the F-35. At the same time we need to address the challenge of a limited number of air assets and a growing demand for Air Power. It is paramount that we utilize the F-35's 5th generation capabilities for the greater good of NATO as a whole. Firstly, the F-35 will be the new spearhead to take on the most challenging tasks in the air and to confront enemy air defences. Secondly, we may also consider using the F-35 as a force multiplier e.g. in the role of forward Battlefield Managers. Through enhanced command and control, information sharing, and decision making, the F-35 can enhance and leverage the capabilities of 4th generation platforms in and above the battlefield. Information superiority is – as it has always been – one of the main measures of battlefield competition. 5th generation air platforms should form the nucleus of a joint and combined force leveraging information superiority to execute operations.

For many years to come, 4th generation platforms will continually form the backbone of NATO operations, while 5th generation platforms, like the F-35, will function as force multipliers, augmenting the collective effect of the whole of NATO operations. This will be much the same as we saw with the introduction of Airborne Warning and Control Systems (AWACS) and expect to see in the future with the Alliance Future Surveillance and Control capability. It is therefore imperative that we vigorously train operations with mixed 4th and 5th generation platforms so our combined NATO forces – during live combat operations – will be able to operate in unity.

The F-35 undoubtedly brings about many advantages, both in a national and an alliance context, but what are some of the challenges that you expect to see from a Danish perspective, with regards to operating the F-35?

The transformation from a 4th generation Air Force into a 5th generation Air Force is a challenge to both our nation and our alliance. To quote Air Marshal 'Geoff' Brown, former Australian Chief of Air Force: *'We cannot be complacent, and assume that simply by having the F-35A aircraft we have a 5th generation capability. We need to think about how we employ our air combat forces, as a system of systems. Developing and evolving concepts and tactics that best exploit the new capabilities are vital.'* The core of this adaption and development is our airmen – the key element in all we do. Our ability to deliver effects is directly proportional to our ability to have the right personnel with the right attitude and qualifications, properly equipped at the right place and at the right time. If we fail to do this, we will not be able to deliver the desired effect, and thus we will fail. This is true in regard to every position in the chain, from the military security personnel to the pilots and the military commanders. Without skilled personnel, we cannot launch the jets, and thus we cannot provide Air Power. Consequently, we must ensure that our airmen are organized, trained, and equipped to face the challenges. It has long been a motto that we must 'train as we fight', but instead we should start looking at how we will fight in the near future, and start training for it today.

Since the fight of the near future is going to be different from the fight of today, it is absolutely essential that we have the proper means to train for it. The limited size of our training airspace and what we are able to replicate in live training is already a challenge for the fight of today, and will be even more so in regards to the fight of tomorrow. Therefore, we need to look at establishing larger training airspaces in northern Europe, which could serve as a frame for combined live training with players from all of NATO. In time, this must be complemented with a more comprehensive use of simulation than we have seen before, since many of the threats we need to train against, and the scenarios in which we need to train, only can be produced in a simulation environment.

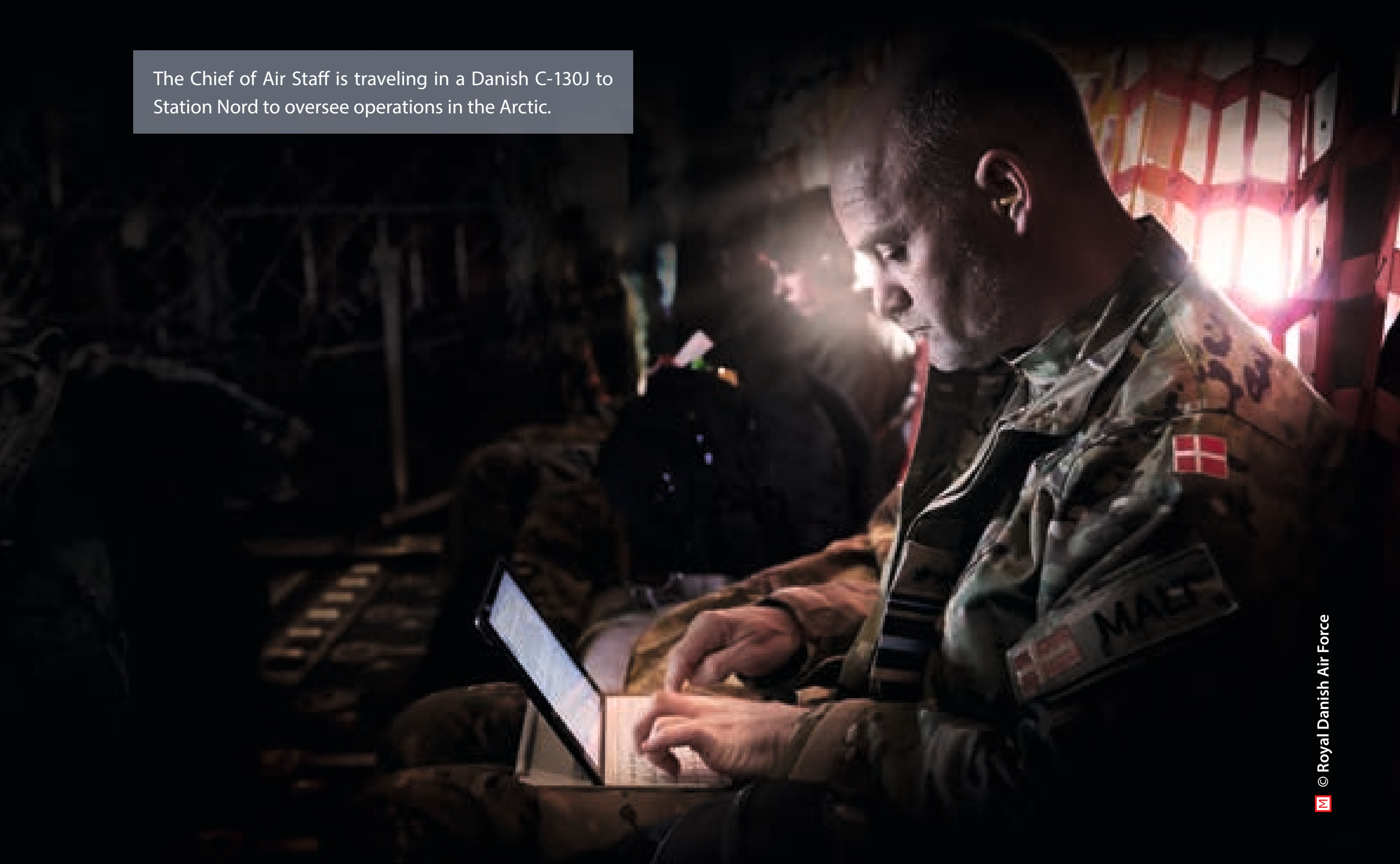
From a national perspective, we are looking at ways and means to optimize the use of the F-35. With a limited amount of aircraft and considering the cost of flying hours, it is vital that we optimize the training output as much as possible. This in turn forces us to look at other options to achieve our training objectives e.g. in terms of red air support. One such option, which we must consider, could be to engage with a commercial partner to fill parts of the red air requirements. At the same time, in the first years to come, we must seek to increase the combined training across NATO countries, which would serve to both facilitate training with mixed 4th and 5th generation platforms and to provide high quality opponents to both platforms as well.

Looking a bit further into the future, we see great potential in Live, Virtual and Constructive (LVC) training. If we can manage to overcome the issues of classification and the technicalities of linking our assets, we will have a powerful tool to ensure increased interoperability and training quality of our combined NATO platforms. At the same time LVC training will lower the cost of training, by reducing the necessity of dedicated platforms for red air, and the need for deployment in order to train with other nations. For a small Air Force with a tight budget, it is imperative that we seek to optimize and make every penny count in everything we do. This is why I am a profound advocate for resolving the classification issues regarding LVC training. If we are going to fully implement LVC training, and truly benefit from it, we need to 'cut the red tape' and overcome the restrictions of data release. Only then, when we are able to share classified information throughout our alliance, we will be able to link our platforms together and harness the enormous potential of LVC training. Doing this will benefit every nation in the Alliance and leverage the joint and comprehensive capabilities of NATO as a whole, by increasing cohesion in the way we operate. Security is paramount to safe guard operations, but we must find ways not to limit our chances to train for them. Consequently, we must continually seek to improve the way we train, so we one day will be able to simulate fully combined and joint combat missions, by linking assets from all services across multiple nations from all over the world.

We all have great expectations to what the F-35 is capable of, but are we overselling the F-35, since there must be limits to the effect of a single tactical level platform in relations to the entire arsenal of NATO platforms?

We do not regard the F-35 as just a new and improved fighter; a 'Super F-16' if you will. The F-35 has the potential of providing tactical applications with strategic effect. Therefore one could argue that the F-35 has the potential of a strategic platform. The argument being, that the F-35 – just like the AWACS – is de facto a force multiplier, capable of leveraging the combined capabilities of NATO.

With fully integrated 5^{th} generation Air Forces within the alliance, NATO will wield a combined force that is agile and adaptive, and able to gain, maintain, and



The Chief of Air Staff is traveling in a Danish C-130J to Station Nord to oversee operations in the Arctic.

The Chief of Air Staff addresses soldiers during a visit to the Joint Movement and Transportation Organization, Air Base Karup.

exploit air superiority – Air Power being a prerequisite for all joint operations – in an ever-changing context. This will allow NATO to maintain its own freedom of action in the air, space, electromagnetic, and cyber domains, and at the same time deny our opponent the exact same freedom. To quote Giulio Douhet *'Victory smiles upon those who anticipate the changes in the character of war, not upon those who wait to adapt themselves after the changes occur.'*

The F-35 has the ability to engage in operations throughout the entire spectrum of conflict today and in the future, and provide NATO domination in and above the battlefield. Fifth generation technology gives NATO the agility to adapt to an ever-changing world, and provides the alliance with coercive options and credible conventional deterrence against advanced and determined peer-level adversaries for many years to come, ultimately enabling the alliance to win our nations' wars.

From a national Danish perspective, which was also pointed out by Dr. Gary Schaub Jr. in his report 'Learning from the F-16', the F-16 gave Denmark the strategic agility to change the way we operated in coherence with our allies, due to the communality of the F-16 across many users, the large quantities produced and the benefit from having very large partners. This is also going to be the case with the F-35. For this reason, the F-35 is going to make a relatively small Air Force, like the Royal Danish Air Force, powerful and highly relevant for decades to come.

Sir, thank you for your time and your comments. ●

Major General Max Arthur Lund Thorsø Nielsen
is the Chief of Air Staff in Defence Command Denmark. He joined the Royal Danish Air Force in 1983, graduated from officers training in 1988 with the rank of First Lieutenant and was assigned to the Control and Reporting Group, 602 Squadron, at Skrydstrup Airbase. In the years between then and now, Major General Nielsen has been assigned to: CAOC 1 Finderup, Tactical Air Command Denmark, the Danish Ministry of Defence and the Royal Danish Air Force Officers Academy. He has also served as the Deputy Danish Military Representative to NATO and Senior Military Assistant to the Chairman of the NATO Military Committee. In 2005 he did a tour as the Military Assistant to the Deputy Commander with the NATO Training Mission in Iraq. Furthermore he has attended both Air Command and Staff College in the US and NATO Defence College in Rome, Italy. He was promoted to Major General and appointed Chief of Air Staff – Defence Command Denmark in 2014. In November 2017 he will be appointed as Vice Chief of Defence, and promoted to Lieutenant General.

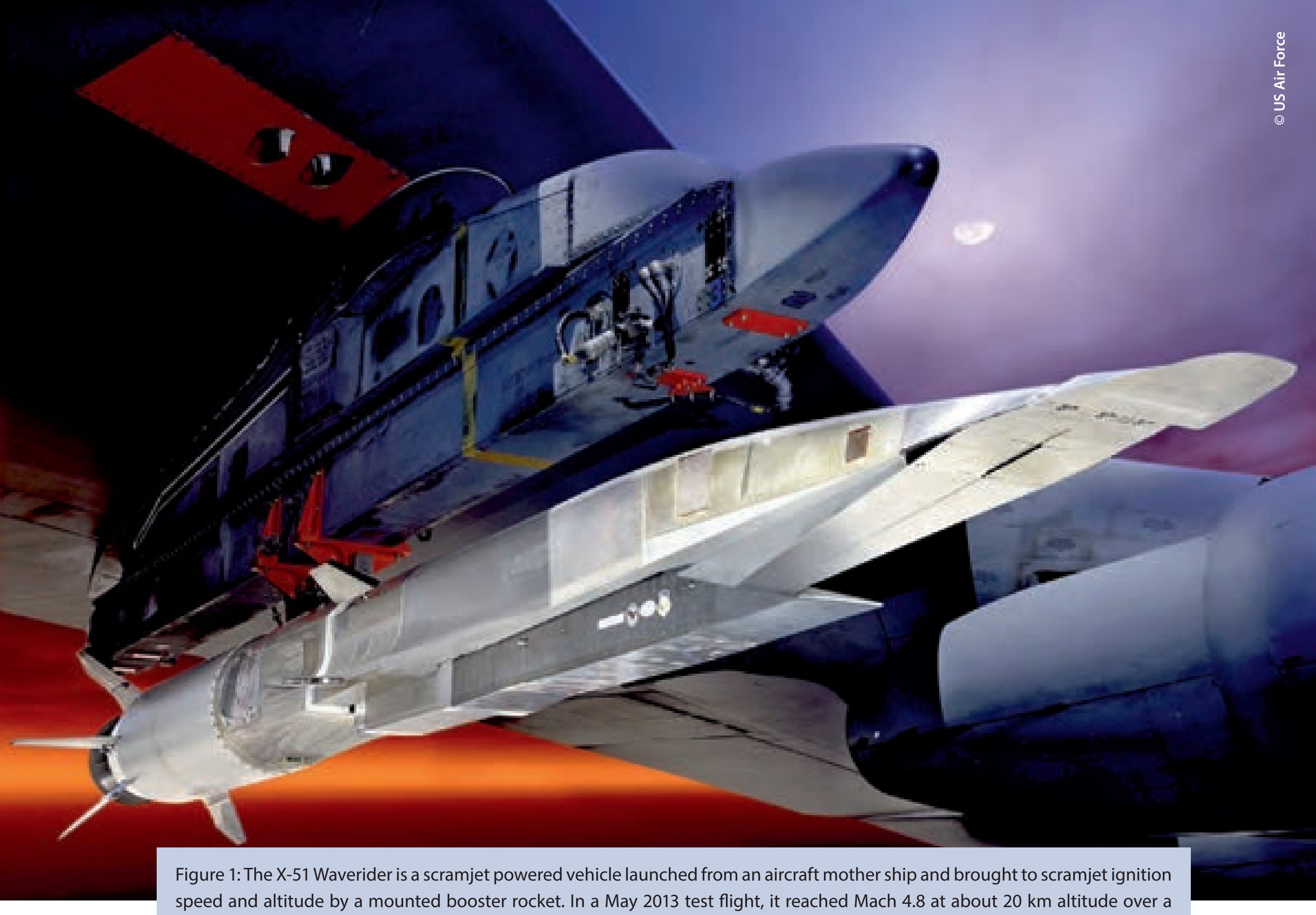


Figure 1: The X-51 Waverider is a scramjet powered vehicle launched from an aircraft mother ship and brought to scramjet ignition speed and altitude by a mounted booster rocket. In a May 2013 test flight, it reached Mach 4.8 at about 20 km altitude over a period of 210 seconds.

Hypersonic Vehicles

Game Changers for Future Warfare?

By Dipl.-Ing. Hans-Ludwig Besser, DEU, Technical Director (ret.) Bayern-Chemie GmbH, subsidiary of MBDA Missile Systems

By Dr.-Ing. Dennis Göge, DEU, Executive Board Representative and Programme Coordinator Defence and Security Research, German Aerospace Center (DLR)

By Mr Michael Huggins, USA, Chief Engineer Aerospace Directorate, Air Force Research Laboratory (AFRL)

By Mr Alan Shaffer, USA, Director Collaborative Support Office (CSO) of NATO's Science & Technology Organisation (STO)

By Dr.-Ing. Dirk Zimper, DEU, Executive Officer Applied Vehicle Technology (AVT) Panel, Collaborative Support Office (CSO) of NATO's Science & Technology Organisation (STO)

Introduction

Hypersonic technologies offer potential solutions and applications that could have a strong impact on doctrine and conduct of future military operations. Different applications are conceivable for hypersonic flight vehicles in order to enable new or advanced military capabilities. Most obvious is the rapid delivery of weapons. Serving the 'speed is life' tenet, high speed would allow for rapid regional or global strikes against time critical targets from standoff distances, while keeping the launch platform out of highly contested areas. As adversaries push out the boundaries of contested areas with advanced Anti-Access/Area-Denial (A2/AD) capabilities involving most modern Integrated Air Defence Systems (IADS), hypersonic flight counters the trend and allows greater standoff operations for first strike. In addition, the extreme speed of hypersonic penetrating systems makes kinetic intercept by the adversary very difficult.

This essay is based on a presentation given on behalf of the Applied Vehicle Technology (AVT) Panel at the 2016 NATO Science & Technology Symposium on 'The Future of Warfare', a collaborative venture between the NATO Science and Technology Organization (STO) and Allied Command Transformation (ACT).[1] The remainder of the article will be split into two parts. The first part will provide an introduction to hypersonic flight, the current achievements in related research, experiments, and the further science and technology challenges concerning hypersonic vehicle development. The second part will explore the feasibility, benefits, and timeline projection of potential future military applications, concluded by a summary and remaining considerations.

Part A – An Introduction to Hypersonic Flight

Research, Experiments, Science & Technology Challenges

Definition and Types

Hypersonic flight has no agreed upon scientific definition but is typically understood as flight within the atmosphere at speed of Mach 5 and beyond, which is five times the speed of sound. Generally, three different vehicle types may be considered for the hypersonic flight regime:

Boost glide vehicles. An unpowered hypersonic vehicle is carried to altitude (boosted) by a rocket, detaches in the vicinity of 100 km altitude, and subsequently glides on the top of the atmosphere at speeds of 8–10 Mach. This type is also known as hyper-glide vehicle (HGV).

Supersonic Combustion Ramjet (SCRJ) powered vehicles. These are variants of a ramjet (RJ) air-breathing jet engine in which combustion takes place in supersonic airflow throughout the entire engine. This allows the vehicle to operate at considerably high speeds, theoretically getting efficient at about Mach 5. Obviously, these vehicles need to fly lower in the atmosphere to ensure the oxygen supply for the engine.

Exo-atmospheric ballistic missiles. These are the classical rocket-powered exo-atmospheric ballistic missiles, which are not further discussed in this paper, even though they operate in the hypersonic speed regime.

History and Present Status of Research

Research in hypersonic flight has a long history[2] reaching back to the X-15 program, which aimed at preparation for space-flight. The X-15 experimental, manned vehicle with liquid rocket propulsion reached a speed record of Mach 6.7 at an altitude of 59 km in 1967. The Space Shuttle and other re-entry vehicles pass though the hypersonic regime when entering the atmosphere (80 km altitude) at Mach 20+ and decelerate during the dive. Numerous hypersonic research experiments follow a similar re-entry flight-path with interim pull-up/glide and manoeuvring phases.

The dream of an operational powered reusable hypersonic vehicle is not new. The US embarked on a major research project in the 1980s to develop a hypersonic, reusable single stage to orbit passenger 'airplane'. This program was called the 'National Aerospace Plane (NASP)'. In 1986, US President Ronald Reagan publicly talked about a plane that would fly from New York to Tokyo in two hours, increasing belief that hypersonic platforms were close to reality. NASP was cancelled in 1992 as the technology proved to be too difficult, but the scientific knowledge gained through ten years of research set the stage for the current generation of hypersonic vehicles. This theme of program termination after learning much about the basic science is recurring in hypersonic vehicle research, which has led to episodic advances in technology.

Research is typically conducted in cycles. The results of one research campaign are used to improve modelling as well as to define follow-on activities. Based on modelling, ground testing (both static and in wind tunnels) and live flight experiments, current research activities are investigating fundamental hypersonic phenomena, materials, components, and the technologies for flight control, navigation, instrumentation, and propulsion.

Hypersonic research is currently conducted by the USA, Russia, China, and Australia, and at a more modest scale by Japan, France, and Germany as well as to some extent by India.[3] The Technology Readiness Level (TRL) for hypersonic flight vehicles lies at or below 6 (i.e. prototype demonstration in a relevant environment).[4] However, the systems being developed and tested today are mature enough to let us believe they will be fielded in the foreseeable future.

Experimental Boost Glider Vehicles

Most of today's hypersonic research vehicles have no internal propulsion, i.e. they are boost gliders. Some of the more notable recent experimental vehicles include:

- **Advanced Hypersonic Weapon (AHW).** A boosted glide vehicle launched by the United States Army Space and Missile Defense Command in November 2011 from the Pacific Test Range. The AHW flew 3,700 km in 30 minutes (average speed Mach 6), striking a target at Kwajelin Atoll.
- **Chinese DF-ZH.** Open source information indicates that China tested a boost glide hypersonic delivery vehicle called the DF-ZH (original name WU-14), with speeds Mach 5 to Mach 10. It is assumed that the boost glide body can be mated with both intercontinental and theatre ballistic missiles. There have been at least seven flights of the DF-ZH.
- **Russian Unmanned Hyper Glide Vehicle.** In April 2016, the Russians conducted and announced a flight test of a new vehicle YU-71. Specific capabilities of this vehicle are not known.[5]

Experimental SCRJ Powered Vehicles

Other experiments focused on testing SCRJ powered vehicles, as by the following examples:[6]

- **HyShot II Experiment.** In July 2002, the Australians conducted a low cost experiment using a sounding rocket to carry an SCRJ powered vehicle (the 'HyShot II') to exo-atmosheric altitudes. It then separated, re-entered the atmosphere, and ignited at about Mach 7.6 to stay in powered flight for six seconds.
- **X-43 (Hyper-X Program).** The X-43 SCRJ powered vehicle was part of the US National Aeronautics and Space Administration (NASA)-led Hyper-X program. A winged booster rocket (the Pegasus) with the X-43 on top was drop launched from a Boeing B-52 and brought the stack to target speed and altitude. Once SCRJ ignition speed (Mach 4–5) was reached, the X-43 detached from the Pegasus and flew free using its own SCRJ propulsion. In a test conducted in November 2004, the X-43 accelerated to Mach 9.6 at up to 34 km altitude and reaching a burn time of roughly 12 seconds.
- **X-51 Waverider.** Built by Boeing for the United States Air Force (USAF), the X-51 Waverider was comparable in size to the X-43. It is also launched from a B-52 aircraft, but with a Minotaur booster rocket (see Figure 1). Designed for longer duration

flight, it reached Mach 4.8 at about 20 km altitude over a 210 second SCRJ powered flight segment, in May 2013).

In comparison, the Lockheed SR-71 Blackbird, which was the fastest operational USAF aircraft designed for high altitude reconnaissance operations, reached Mach 3.3 at 25 km altitude in the 1990s.

The HIFiRE Program

The Hypersonic International Flight Research and Experimentation (HIFiRE) Program was a US-Australian collaboration, which conducted a multi-flight campaign as typical for hypersonic research.[7,8] Lasting from 2009 to 2016, the program resulted in seven launches to examine different aspects of hypersonic flight to include flight dynamics and powered flight (see Figure 2). Experimental vehicles were rocket launched, lifted to high or even exo-atmospheric altitude and separated from the booster. Then they dove or glided down through the atmosphere with high speed, gathering data, performing manoeuvres and sometimes adding another SCRJ powered phase. Some vehicles had features for final recovery to allow post flight inspection.

The Sharp Edge Flight Experiment (SHEFEX) program conducted by the German Aerospace Center is another example for hypersonic flight investigations that followed a similar approach.[9]

Disasters and Failures

An example for the extreme environment at hypersonic speed is given by the Space Shuttle Columbia disaster in 2003. Here, the Thermal Protection System of the left wing was damaged at launch, allowing hot gas to penetrate during re-entry and to destroy the internal wing structure, leading to the tragic loss of crew and vehicle.[10,11]

Another catastrophic failure happened during a test of the Hypersonic Test Vehicle (HTV-2), as conducted by the Defense Advanced Research Projects Agency

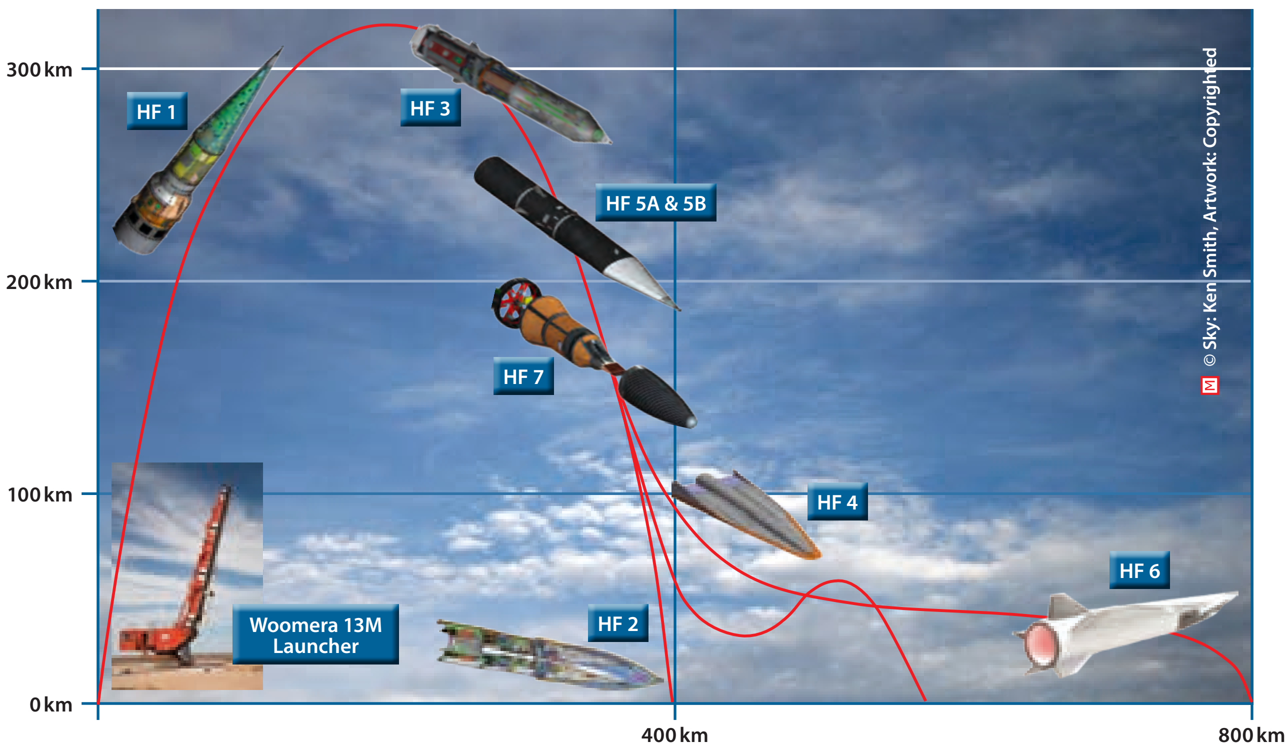


Figure 2: Hypersonic flight experiments – example: HIFiRE Program (USA, AUS).

(DARPA) in 2011. HTV-2 was lost after only a few minutes of flight due to extreme heating on the leading edge, which resulted in irregularities in the vehicle skin surface. This test failure demonstrated some further hypersonic flight challenges. At hypersonic speeds, any imperfection results in a growing shock wave around the platform. When the vehicle skin eroded due to heat, the corresponding shock wave system disturbed the aerodynamic stability and forced the vehicle into irrecoverable failure.

While the failure rate of hypersonic vehicle tests is comparable to early aviation flight tests and fiascos, it is very important to note that the technical knowledge gained from these let-downs is immense. Failures, therefore, should not deter further development, especially since NATO nations have successfully flown both boost-glide and SCRJ systems in recent years.

Science & Technology Challenges

Many scientific and technological aspects (such as kinetic heating, force loading, etc.) are unique to hypersonic flight. There is yet too little knowledge available about such factors, which makes hypersonic vehicle design and development extremely challenging. After decades of hypersonic flight research, there are still many problems that need to be solved to get from hypersonic technology achievements to a truly operational hypersonic system.

In a very simplistic way, some challenges of hypersonic flight through the atmosphere are illustrated by a meteor. A meteor enters the atmosphere with a speed beyond 40 km/s (roughly Mach 12) and heats up depending of the thermal conductivity of its materials. The heated outer layers lose strength and may be fragmented by huge drag forces. This can be seen as a kind of cooling, since the most heated material is continuously removed. Depending on its size and composition, the meteor may be totally consumed during atmospheric entry, or it may reach the ground as a meteorite. As demonstrated by the meteor analogy, managing the excess thermal loading is clearly a principal challenge for hypersonic flight. Additional challenges come into play when thinking about the need to navigate and control the hypersonic vehicle.

Thermal and Aerodynamic Forces and Effects

Kinetic heating is a major effect that increases in severity with increasing speed. In brief, heating increases with both velocity and atmospheric density. Figure 3 shows the total temperature as a function of flight Mach number. Even when the recovery temperature acting on a flight vehicle will be somewhat lower, this gives an indication of the heat loads to be expected. The temperature limit with regard to strength for different structural materials is also indicated. High-performance steel and a typical Titanium-Alloy range from 800 Kelvin (K) to 950 K. Molybdenum-Alloys (e.g. Ti/Zr/Mo) are usable up to about 1,700 K, but they are brittle and have a much higher density. Ceramic materials like Carbon Fibre Reinforced Silicon Carbide Composites (C-SiC) can be used even beyond 1,800 K, but they feature a very low strain capability, which limits their application for load carrying structures. Consequently, conventional materials and designs are not applicable for hypersonic flight, while the current class of available advanced materials will limit high altitude (but not exo-atmospheric) flight to Mach 5–6.

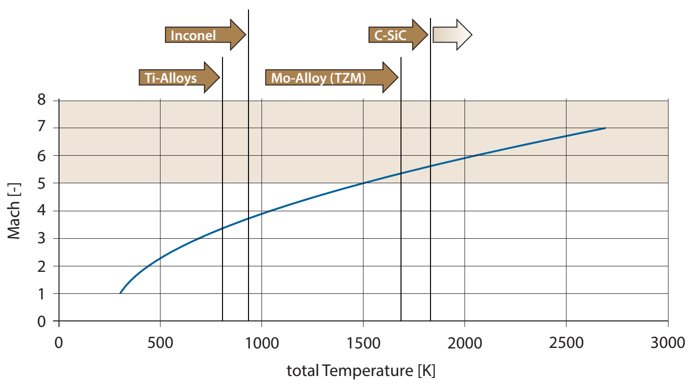


Figure 3: Total temperature depending on flight Mach number application limits of structural materials.

Massive aerodynamic forces at hypersonic flight lead to additional issues. Figure 4 shows the pressure behind a normal shock wave in metric tons per square metre to illustrate the forces acting on a vehicle. At 40 km altitude, a hypersonic vehicle has forces of the mass of a motor car per square metre. This increases to the mass of a truck on a square metre at 20 km altitude. The extreme aerodynamic forces and the extreme kinetic heating have highly transient patterns[12] due to

- shock pattern dominated flow (which caused e.g. the HTV-2 failure);
- complex boundary layer transition mechanisms;
- shock-shock and shock-boundary layer interactions;
- thermo-chemical effects.

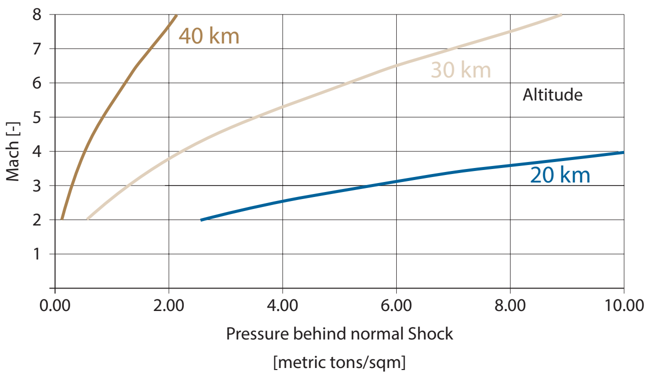
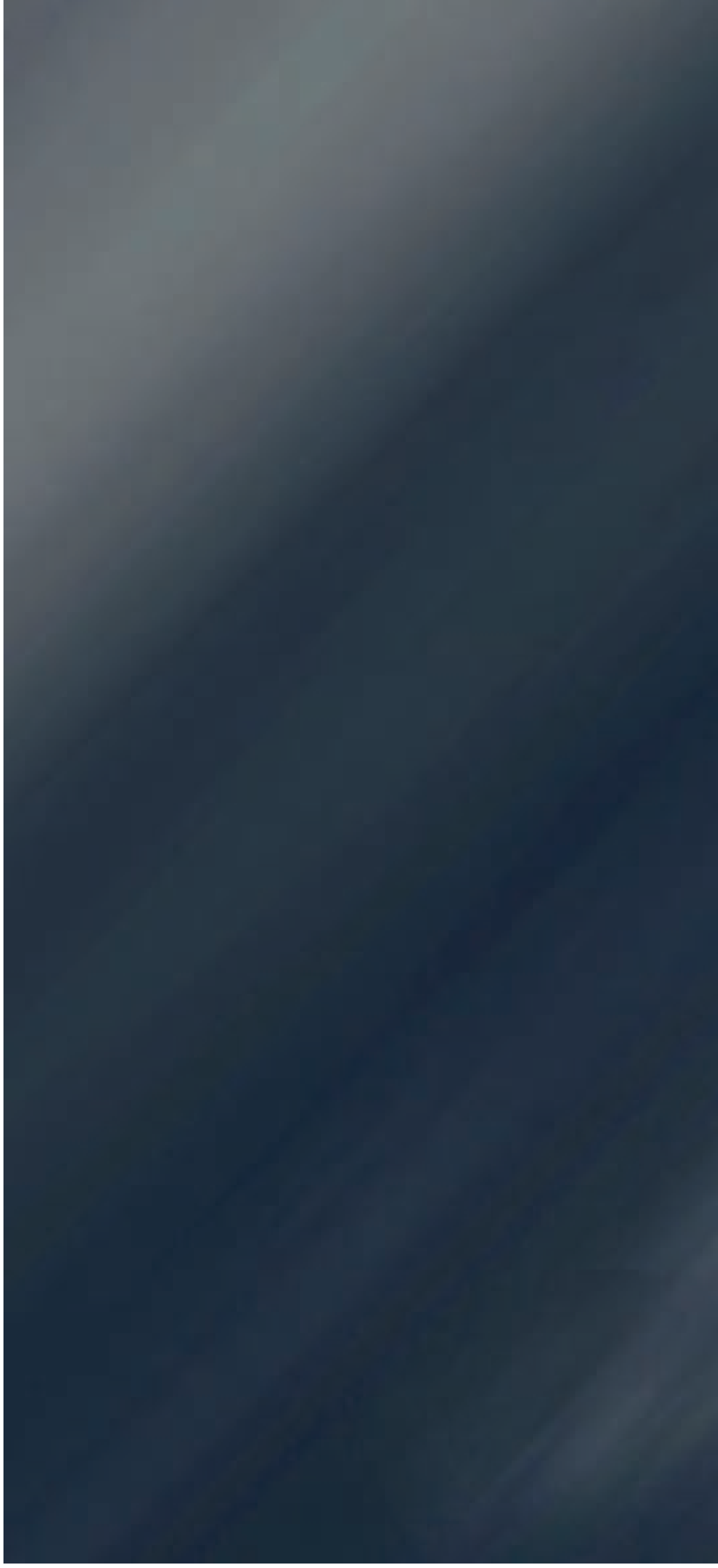


Figure 4: Pressure behind a normal shock vs. Mach number.

Each of these forces as well as the related effects must be understood and dealt with during design and test to develop an operational, repeatable system.

For the vehicle itself, which is typically configured as a wave rider as illustrated in Figure 5, the effects on structural integrity and endurance are among the main challenges.[13] The thermal management to keep structural material strength high enough to carry extreme and highly dynamic structural loads is a key issue. Thermal protection by insulation or ablation delays heat flow into the vehicle structure and offers a viable solution for limited flight duration. Cooling can improve endurance if the fuel of a powered vehicle can be used as cooling fluid or if a cooling fluid can be carried as payload (weight penalty). Of course, a flight duration limit is then induced by the total amount of cooling fluid available in the vehicle.



Besides structural integrity, thermal issues are aggravated by the fact that vehicle equipment, such as control effectors and actuators as well as instrumentation, sensors, and electronics, typically need to be kept at temperatures below about 100°C (370 K) for

Figure 5: HTV-2 was a crewless, experimental hypersonic glide vehicle developed as part of the DARPA Falcon Project. In the two flight tests in 2010/2011 the 'waverider' was carried inside the nose of a Minotaur IV Lite rocket to outer space for the craft to separate from the booster. Both tests were unsuccessful due to lost contact to the glider after a few minutes.

operation. To sum up, it is evident that structural integrity issues of hypersonic flight require technical solutions at the edge or beyond current state of the art.

Another important issue is flight control to keep the vehicle stable while coping with the highly dynamic lift and drag forces.[14]

Challenges for Sustained Hypersonic Flight

Rocket propulsion for launch/acceleration and climb to operational altitude of a hypersonic vehicle is state of the art, albeit problems may arise with very low temperature for ignition and operation. This can occur for configurations which are air-launched from a platform flying subsonic at high altitude for long duration.

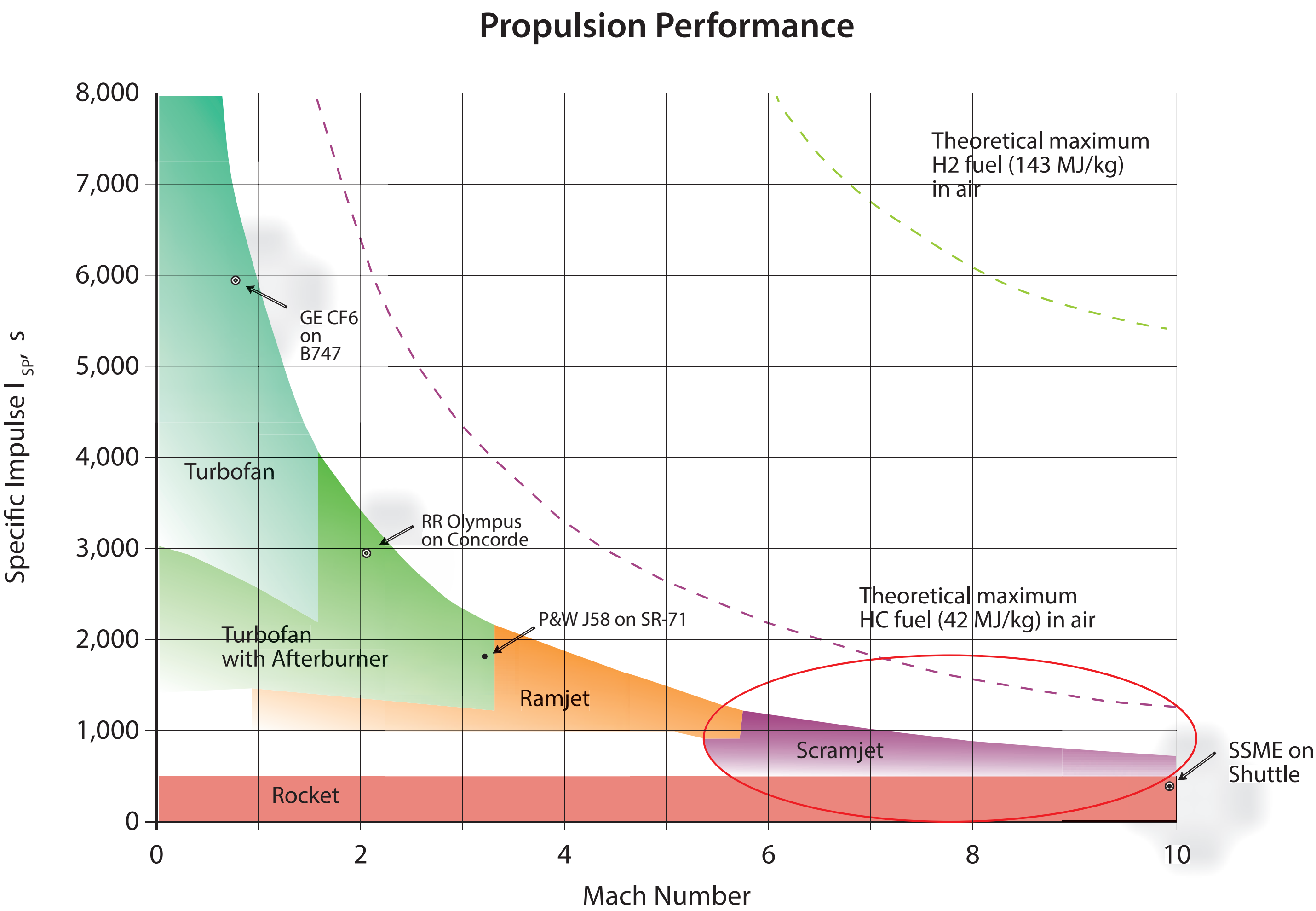


Figure 6: Performance of different propulsion systems vs. Mach numbers.

Another issue is the propulsion for a sustained flight at hypersonic speed, which requires the use of SCRJs.[15,16] While SCRJs have been a research topic for more than fifty years, there are still considerable hurdles to overcome on the way to a reliable propulsion system, especially with regard to longer run times.

Major issues are the use of hydrocarbon storable fuel with regard to ignition, performance, and cooling and air intake performance as well as stability over a sufficient range of speeds/altitudes/angles of attack/sideslip operations.[17]

Figure 6 illustrates the achievable propulsion performance (i.e. the 'Specific Impulse') as a function of Mach number for different propulsion systems.[18]

Extension of the operational regime of the propulsion system to lower Mach numbers will induce the need for combined cycle engine concepts like RJ/SCRJ or Turbo/RJ/SCRJ with even higher complexity.[19]

Vehicle and propulsion issues are highly interrelated and need aligned design concepts and of course, overarching requirements as mass and volume limitations, payload capacity, and affordability need to be considered when we assess the feasibility of a hypersonic flight vehicle.

Part B – Military Utility of Hypersonic Flight

Applications, Timelines, Considerations

Global Strike

The extreme speed of hypersonic systems could become a decisive military advantage when it comes to penetrating enemy defences from a safe stand-off distance. A hypersonic weapon systems could for example cover a distance of 1,000 km in about 10 minutes at Mach 5. For comparison, operational missiles today can fly

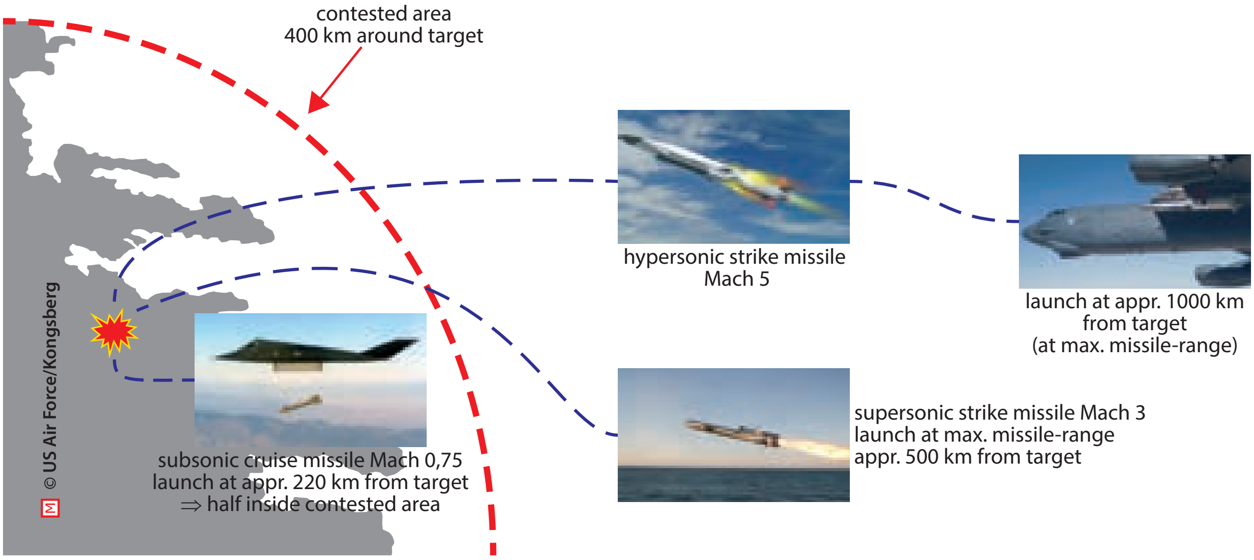
- 500 km at Mach 3 in about 9 minutes (e.g. ASMP-A; French supersonic cruise missile);
- 1,000 km at Mach 0.75 in about 67 minutes (e.g. Tomahawk; US subsonic cruise missile).

Figure 7 illustrates a comparison of the required launch distance for subsonic, supersonic, and hypersonic missile systems, given the objective to hit a target within 15 minutes after launch. An aerial launch platform of a subsonic Mach 0.75 missile would need to get as close as 220 km to the target before missile launch. This means entering deeply into the range ring of modern surface-to-air missiles (SAM) such as the Russian S-400 Triumf (SA-21 Growler), which covers up to 400 km. To launch a supersonic missile, one could keep a distance of up to 500 km, which is only a marginal advantage overcome by further advanced SAM systems in the foreseeable future. High risk to own high-value assets could only be avoided with hypersonic missile systems.

For a global strike range of typically 10,000 km, the flight Mach number of the hypersonic system must be considerably higher to reach the target within a certain limit of time. An Inter-Continental Ballistic Missile (ICBM) would reach 10,000 km in 30 minutes. A realistic goal for Hypersonic Vehicles is to reach Mach 10, which would keep the time-to-target below one hour.

The following sections will address some prospective hypersonic military applications to include the associated technological challenges as well as potential risks.

Figure 7: Launch distances for subsonic, supersonic and hypersonic weapons for a 15 minutes time-to-target requirement.

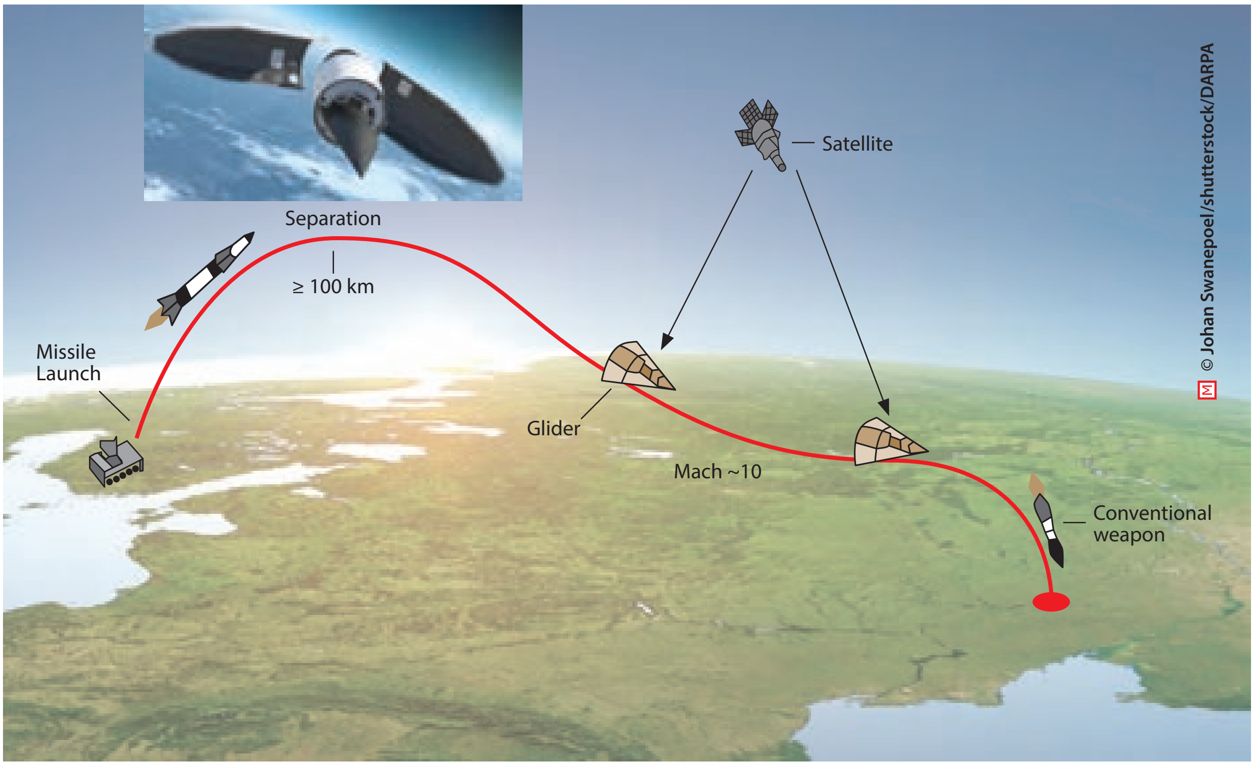


Hypersonic Manoeuvrable Glide Vehicle

Figure 8 shows the mission trajectory of a manoeuvrable glide vehicle. To date, the US, China, and Russia have successfully tested this concept. A boost-glide vehicle would be boosted to high altitude (100 km+), separate from the boost rocket, and perform an unpowered relatively flat glide phase with manoeuvres in the upper atmosphere at around Mach 8–10 before the final dive to the target. Such glider would be much more difficult to intercept than state-of-the-art, re-entry vehicles with a ballistic trajectory. The reason is simple and points to an advantage of non-ballistic trajectories. Current long range strike systems will be detected by ground based radar, which can spot approaching ballistic missiles with much more lead time. At boost-glide altitudes, a ground based system may not detect the vehicle until very late in the flight, making intercept much more difficult.

Boost-glide vehicles would carry conventional warheads to fulfil the global strike requirement. Therefore, the hypersonic glide vehicle would have to be bigger in size and mass than operational BM re-entry warheads. Extreme peak dynamic pressures and temperatures together with aggressive manoeuvres (to evade intercept) are the major challenges for the structural integrity of such vehicles. Typically, time-to-target would be less than one hour. The Circular Error Probable (CEP) will depend on issues like navigation (and communication) means and guidance/flight control precision. Such vehicles could also be used for medium range strike with ranges around 3,000 km+, if launched from a ship or submarine operating near the target region. In this case, there would be a strict volume constraint for the design, to ensure compatibility with existing launch equipment. Another most difficult technical challenge associated with boost-glide is that precise engagement of a target would likely require deceleration to about Mach 3 in the terminal phase. Even then achieving a precise hit will remain very difficult.

Figure 8: Typical mission trajectory of a hypersonic manoeuvrable glide vehicle.



Hypersonic glide vehicles could be a lethal instrument for power projection, but for now, they would require limited range to avoid a nuclear escalation. Early warning systems would likely differentiate the depressed trajectory of such glide weapons from an ICBM's re-entry warhead. On the other hand, the early post-launch ballistic curve of long-range, hypersonic vehicles would probably have considerable similarity with a BM launch and could be detected as easily. If falsely interpreted, this could lead to an undesired and inappropriate reaction of the adversary.

Technically, the boost-glide vehicle is likely to be the first operational system, as the number of global successful tests of prototype systems outpaces any other hypersonic technology by far. An operational system is attainable by 2022–2025. Many research projects are aiming at this goal:[20]

- US: Falcon, HIFiRE, HSSW/TBG (High Speed Strike Weapon/Tactical Boost Glide);
- YU-71 (Russia);
- WU-14 (China).

Hypersonic Cruise Missile

Hypersonic cruise missiles may be used for tactical strike from standoff distances. Flying at Mach 4–6+ at altitudes of 20–30 km, flight time for up to 1,000 km is shorter or comparable to a ballistic missile. Most likely, hypersonic cruise missiles will be air launched from a mother ship (such as a B-52), resulting in a mass- and size-restricted vehicle. Figure 9 illustrates the mission with air launch, a boost and climb phase with an expendable rocket and the cruise to the target with SCRJ propulsion. Typically, the vehicle has to accelerate to about Mach 4–5 for SCRJ ignition. The vehicles will be difficult to detect at launch and to intercept during high altitude cruise and terminal dive.

For this mission, peak temperatures are lower than for the glide vehicle due to lower speed, but integrated heat loads will still be high depending on flight duration. Aerodynamic forces will be higher than for the glide vehicle because of the lower flight altitude, but manoeuvres during the cruise phase will be moderate.

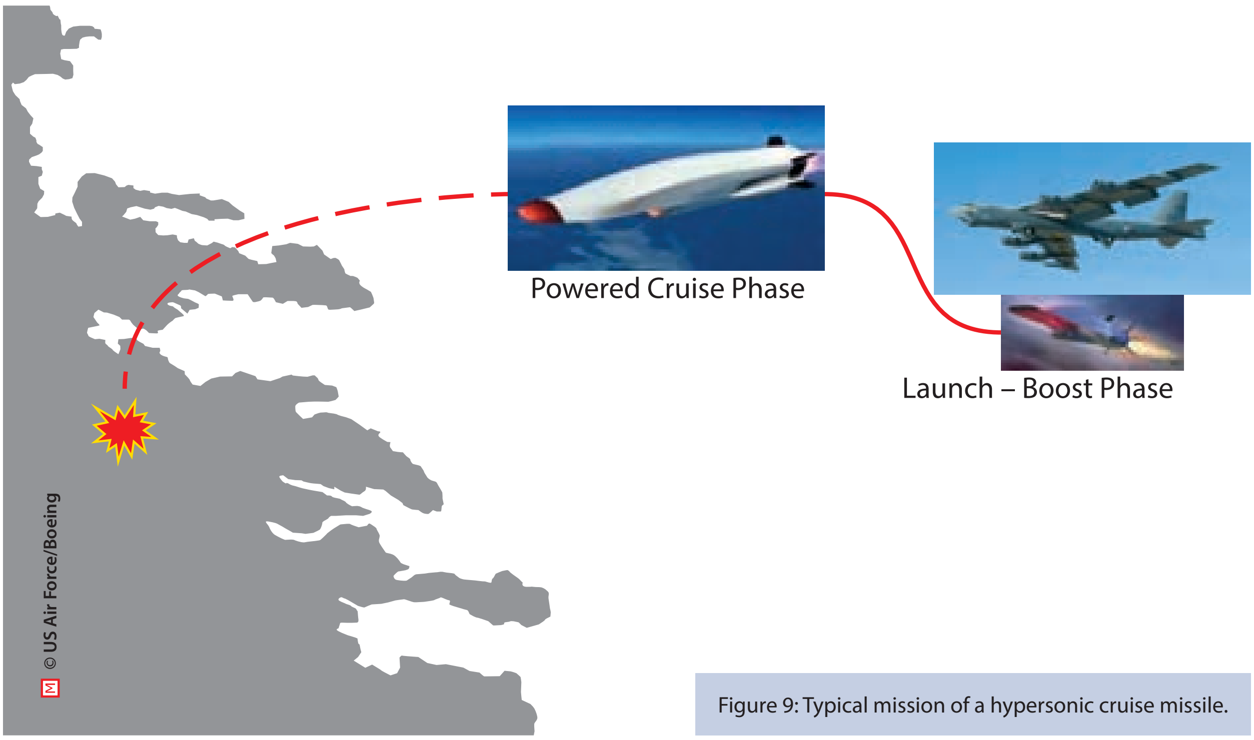


Figure 9: Typical mission of a hypersonic cruise missile.

Long range (1,000 km+) implies vehicle and propulsion endurance in the stretch between 10 minutes up to an hour.

While a hypersonic cruise missile will have many positive attributes, several critical technologies are still in development and are uncertain. Widely unresolved issues relate to structural integrity, propulsion efficiency and endurance, as well as precision of flight control and navigation. The requirement for air carriage to the launch position restricts size and mass of the vehicle with impact on military payload and boost rocket mass. The result is a very complex and expensive vehicle.

Research and concept development in this direction are carried out in the US, e.g. X-51, the High Speed Strike Weapon (HSSW), and the Hypersonic Air-breathing Weapon Concept (HAWC). Russia is reported to field a ship-based hypersonic missile (Zircon[21]; Mach 5–6, range ~250 km) within years and India is working with Russia on the Brahmos II hypersonic missile concept. Reporting indicates that China is also conducting research and development in SCRJ design with the aim to build a hypersonic cruise missile. Figure 10 shows pictures of some hypersonic cruise missile concepts.

Operational readiness of long-range, air-launched hypersonic cruise missiles is very unlikely within the next decade, because of the higher complexity of a powered vehicle in comparison to a glider, but should be attainable within 20 years.

Figure 10: Examples of hypersonic cruise missile concepts.

US X-51 – Hypersonic SCRJ powered experimental vehicle

Russian "Zircon" missile concept (Mockup)

Indian/russian Brahmos II concept (Mockup)

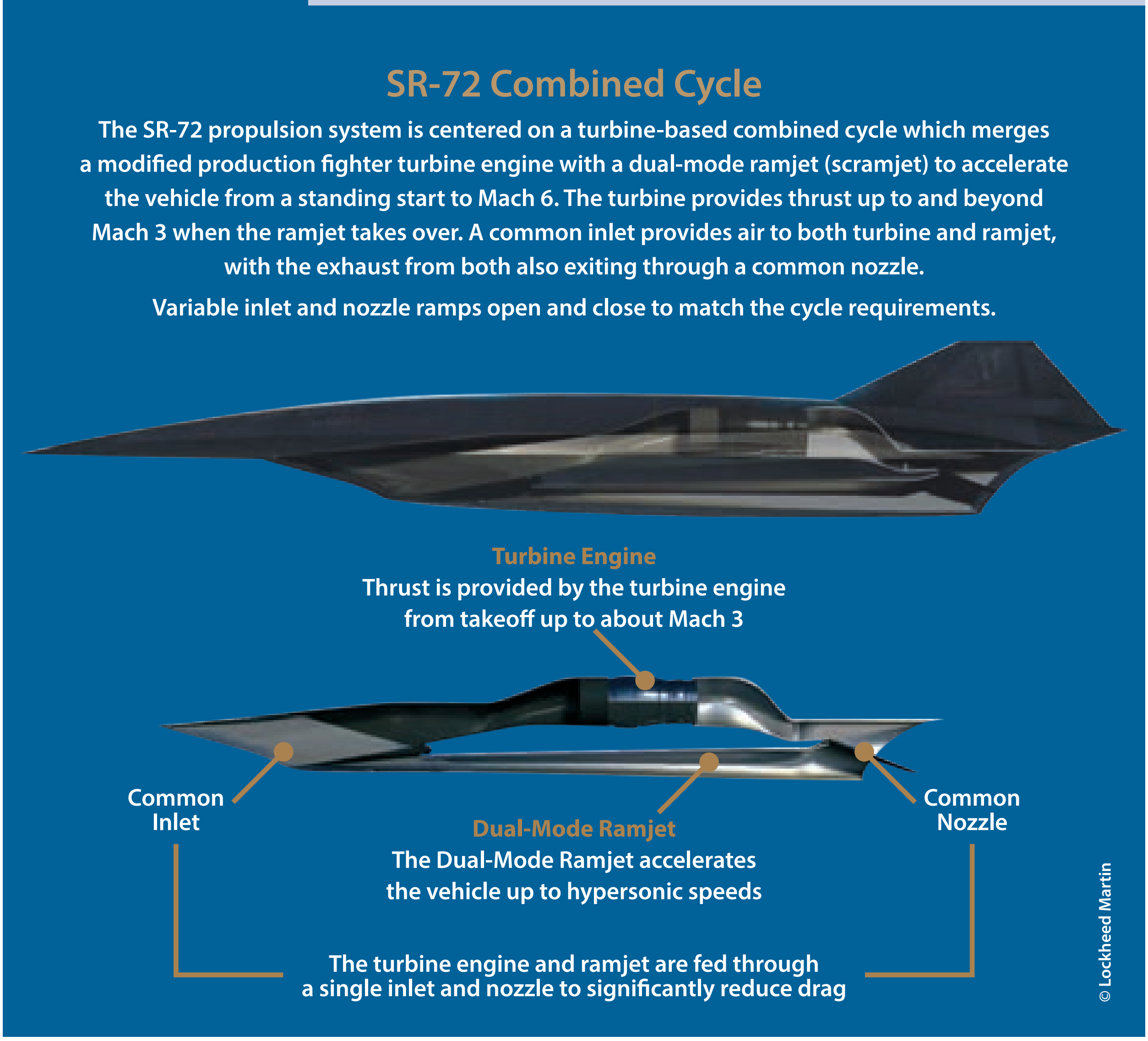
Hypersonic Vehicle for Intelligence, Surveillance, Reconnaissance (ISR)

Looking even more into the future, we can envisage a powered hypersonic vehicle for ISR missions and possibly weaponized for reconnaissance-strike action. This system will likely fly at Mach 5–7 and at altitudes greater than 25 km; it will perform ISR or tactical strike at ranges well beyond 1,000 km and return after its mission. It will be difficult to intercept due to speed and high operating altitude and will be able to perform its mission in areas highly contested by adversaries' enhanced A2/AD capabilities. Potentially, such a system could be more flexible than satellite reconnaissance.

Lockheed-Martin Skunk Works' work on a 'SR-72' (no official name) was first published by Aviation Week & Space Technology in November 2013.[22] It is an unmanned aircraft for ISR purposes, using a complex, combined cycle propulsion (TurboJet/RamJet/SCRJ) system to accelerate to Mach 6, while being able to take off and land like a conventional aircraft. Figure 11 shows the propulsion concept together with an artist's impression of the vehicle. This very ambitious concept is not the only way forward and not the most likely one.

An alternative would be a limited life, partially re-usable or refurbishable vehicle with a propulsion similar to the hypersonic cruise missile. Take off/launch would be from the ground or less likely from an aircraft with a rocket booster. Hypersonic cruise would use SCRJ propulsion (or a combined RJ/SCRJ system), and landing or recovery would likely occur as a glider. Such a concept has a potential to offer lower operating costs than a fully expendable system or a fully re-usable system like SR-72. All issues mentioned for the hypersonic cruise missile apply for this system, significantly increased by the complexity of a re-usable vehicle and an even longer flight duration (greater than one hour). Also, hypersonic speed and external aerothermal effects may pose severe problems for ISR sensor performance (e.g. picture resolution) and data communication links.

Figure 11: Lockheed Martin's Concept of the SR-72 (fully re-usable hypersonic vehicle for ISR).



While the US, Russia and China appear to work on such vehicles, little reliable information is available. Articles can be found depicting propulsion concepts similar to the SR-72.[23]

This operational capability may be reached in the mid-term by 2035+, but a stepwise approach may occur with vehicles flying up to Mach 4 with a more limited range by incorporating existing state-of-the-art technology. For the ISR mission, stealth is still a key factor to allow operation in strongly defended regions, and being feasible with current technology. The US is following this path with the X-47 and RQ-180 subsonic drones.

Hypersonic Endo-Atmospheric Interceptor Missile

Of course, hypersonic vehicles can also be applied for defensive actions. A powered hypersonic interceptor missile could be used against time sensitive and high value aerial targets (also for ballistic missile defence) and would have the potential to counter adversary hypersonic vehicle threats. The interceptor missile could be ground or air launched, boosted to the take-over Mach number for the SCRJ sustained propulsion and could cruise to the target at Mach numbers between 6 and 9. Typical range of such missiles will be hundreds of kilometres with an operational ceiling beyond 30 km.

Technology issues for such interceptor missiles would be similar to a hypersonic cruise missile, but severity is increased by the higher Mach number regime and the need for aggressive manoeuvres. On the other hand, structural issues are alleviated by lower integrated heat load due to the relative short flight duration less than five minutes). High precision guidance and flight control to hit the target will be another important challenge for these missiles.

A military capability may be achievable within the same timeframe as the hypersonic cruise missile, because the technical issues are similar. Again, a stepwise approach is likely, first using more mature technology for Mach 4–5 and conventional, ramjet propulsion with subsonic combustion system. Figure 12 shows

Launch configuration with tandem booster and integral booster in the ramjet combustor case

Cruise configuration with throttleable ducted rocket propulsion

Figure 12: Concept for a ground launched endo-atmospheric interceptor (Mach 5).

an example with a German concept study for a ground-launched Mach 5 endo-atmospheric interceptor missile.[24]

Conclusion

The game-changing quality of hypersonic technologies has been recognized by the US[25] as well as by the Alliance. Without any doubt, hypersonic flight can offer important advantages for prompt strike over mid to long ranges into highly contested environments, for flexibility of ISR and for penetration of enemy air defence. Hypersonic systems can be applied to neutralize a singular urgent threat but potentially – if available in sufficient numbers – also to decapitate adversary command, control, communications, and information systems. Published concepts aim at conventional ordnance, but the implementation of nuclear warheads could be an option.

Most notably, the technological advantage is not only on the Alliance's side. Potential adversaries are striving for similar hypersonic flight capabilities. Russia has had a long history of hypersonic research and recently began cooperating with India in this field. China also appears to massively invest in hypersonic flight research. China owns the world's largest hypersonic wind tunnel (the JF-12) capable of producing speeds of up to Mach 9[26], while the NASA hypersonic wind tunnel reaches only up to Mach 7. There have been seven reported tests of the Chinese DF-ZH hypersonic glider over the past two years. However, the frequency of open source publications about China's basic and applied hypersonic research has significantly dropped in the recent past, indicating that the country has a growing military interest and tendency to consider the results as classified information.

Research and development for hypersonic flight is extremely complex and expensive, due to

- the variety of complex technical challenges;
- the limited capability of ground testing even in highly specialized costly facilities;
- the high effort for flight experiments.

The path to operational hypersonic systems will therefore take time, and an initial capability is to be expected no earlier than 10 to 20 years from now. Its development will demand continued investment through a series of hypersonic test campaigns due to the wide area of unresolved technical issues today. This will likely result in very complex and expensive hypersonic systems with limited ordnance payload, whose cost effectiveness will remain to be judged. A stepwise approach might therefore be the most feasible solution: Stay below the hypersonic regime first, allow near term development using evolved materials and technologies like ramjets, but make provisions for the longer term incorporation of hypersonic SCRJ capabilities.

Besides the financial and technical hurdles, the following operational and political issues should be considered:

- How to ensure operational procedures preceding hypersonic weapon use do not reduce its time advantage?
- How much 'autonomy' is acceptable for such a critical weapon system? It will need to fly highly automated to its pre-determined targets. Is there a need and feasibility for a final 'human' decision on target validity during the terminal phase (the man in the loop)?
- How big is the risk that the launch of a long range glider is detected by a potential adversary (who may not even be the target) and leads to misconception and catastrophic overreaction?
- Is there a risk, that such capable (conventional) weapon systems affect the balance of nuclear deterrence and lower the threshold for hostile actions?

So What?

Recent technological advance has brought us closer to fielding an operational hypersonic system, first boost-glide, then air-breathing cruise missile. While the West is advancing, so are Russia and China. The potential strategic and tactical applications of hypersonic flight are such that the West must remain involved in research and development so as to not be put at a capability disadvantage. In the past, funding of high speed/hypersonic research in NATO nations was very discontinuous and not always purposeful, which led to fluctuations in the TRL level and cost increase due to the inefficiency of a stop-and-go development process. This implies that decision makers must develop (based on clear political and military objectives) a long-term roadmap, which is strictly followed with sustained funding (nationally or cooperatively). Therefore, it could be very efficient to commonly fund the necessary fundamental research, as in the example of the US/AUS/DEU HIFiRE collaboration. Last but not least, overcoming commonplace hurdles of information sharing will be key to success for collaborative hypersonic weapons development. ●

1. NATO Science & Technology Organization, 'NATO S&T SYMPOSIUM – The Future of Warfare', Technical Evaluation Report, 2016 [available on the STO website at http://www.sto.nato.int].
2. AVT-234 Lecture Series, 'Hypersonic Flight Testing', Educational Notes, 2014 [DOI: 10.14339/STO-EN-AVT-234].
3. Malenic, Marina, et al., 'Hypersonic hustle: Global efforts raised to satisfy need for speed', In: IHS Jane's International Defence Review, Apr. 2016.
4. Ibid. 3.
5. Sara Malm, 'Russia tests new "hypersonic glide vehicle" capable of breaching missile defences and launching nuclear warheads', [electronic article available on http://www.dailymail.co.uk], 22 Apr. 2016 [cited 11 Jan. 2017].
6. Bowcutt, Kevin G., 'Hypersonic Gliders and Air-Breathing Vehicles: Vehicle Design and Flight Testing Challanges and Requirements', In: AVT-234 Educational Notes on 'Hypersonic Flight Testing', 2014 [DOI: 10.14339/STO-EN-AVT-234].
7. Dolvin, Dolvin, 'High Speed Flight Research Insight Briefing' delivered at: USAF AFOSR RTA Program Review; USAF Arnold Engineering Development Center Tennessee, USA; High Speed Systems Division Aerospace Systems Directorate Air Force Research Laboratory, 17 Jul. 2015.
8. Bolender, Michael A., et al., 'HIFiRE 6: Overview and Status Update 2014', 20th AIAA International Space Planes and Hypersonic Systems and Technologies Conference, International Space Planes and Hypersonic Systems and Technologies Conferences, (AIAA 2015-3537), 2015.
9. Weihs, Hendrik, 'SHEFEX I, II and III Mission Design'. In: AVT-234 Educational Notes on 'Hypersonic Flight Testing', 2014 [DOI: 10.14339/STO-EN-AVT-234].
10. Gebhardt, Chris, 'Columbia (OV-102): A Pioneer to the End', [electronic article available on www.nasaspaceflight.com], 2011 [cited 13 Aug. 2016].
11 Camarda, Charles J., 'Space Shuttle Return-to-Flight Following the Columbia Tragedy'. In: AVT-234 Educational Notes on 'Hypersonic Flight Testing', 2014 [DOI: 10.14339/STO-EN-AVT-234].
12. Gülhan, Ali, et al., 'Aerothermal Postflight Analysis of the Sharp Edge Flight Experiment-II', Journal of Spacecraft and Rockets, 2015 [DOI: 10.2514/1.A33275].
13. Franze, Marius, 'SHEFEX II – An Aerodynamic and Structural Post-Flight Analysis'. In: ATMOSPHERIC FLIGHT MECHANICS CONF. AIAA Atmospheric Flight Mechanics Conference, 13–17 Jun. 2016, Washington D.C., USA.
14. Adamczak, David W., Bolender, Michael A., 'The Flight Dynamics of the HIFiRE Flight 6 Research Vehicle', AIAA Atmospheric Flight Mechanics Conference, AIAA SciTech, (AIAA 2015-0528), 2015.
15. Ibid. 6.
16. Tirtey, Sandy C., et al., 'SCRAMSPACE: Radical-Farming SCRJ for Access to Space'. In: AVT-234 Educational Notes on 'Hypersonic Flight Testing', 2014 [DOI: 10.14339/STO-EN-AVT-234].
17. Jackson, Kevin R., et al., 'Mach 6–8+ Hydrocarbon-Fueled SCRJ Flight Experiment: The HIFiRE Flight 2 Project', Journal of Propulsion and Power, Vol. 31, No. 1, pp. 36–53, 2015.
18. Jackson, Kevin R., et al., 'Mach 6–8+ Hydrocarbon-Fueled Scramjet Flight Experiment: The HIFiRE Flight 2 Project', Journal of Propulsion and Power, Vol. 31, No. 1, pp. 36–53, 2015.
19. Villacé, Víctor Fernández, et al., 'Precooled Air Turbo-Rocket Engine'. In: AVT-234 Educational Notes on 'Hypersonic Flight Testing', 2014 [DOI: 10.14339/STO-EN-AVT-234].
20. Sara Malm, 'Russia tests new "hypersonic glide vehicle" capable of breaching missile defences and launching nuclear warheads', [electronic article available on http://www.dailymail.co.uk], 22 Apr. 2016 [cited 11 Jan. 2017].
21. Russia's Lethal Hypersonic Zircon Cruise Missile to Enter Production; Dave Majumdar, The National Interest Magazine, 22 Apr. 2016.
22. Skunk Works Reveals SR-71 Successor Plan; Guy Norris; Aviation Week & Space Technology, 4 Nov. 2013.
23. Lin, Jeffrey; Singer, P.W., 'Chinese Hypersonic Engine Wins Award, Reshapes Speed Race? China starts flying at Mach 5', Popular Science/Eastern Arsenal, [electronic article available on http://www.popsci.com], 8 Oct. 2015.
24. Bayern-Chemie GmbH (an MBDA Company), internal documentation, 2015.
25. James, Deborah L. (Secretary of the Air Force), 'America's Air Force: A Call to the Future', Jul. 2014.
26. Ibid. 5.

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holds a degree for technical physics from the Technical University Munich (Germany). Having worked in different divisions of EADS predecessor companies, he has more than 35 years of experience in the development of tactical missile propulsion and inherent missile system issues. He was engaged in various technology demonstrators (hypervelocity) and missile systems like ALARM, VT1, and especially the development of the ramjet propulsion for the European Air Dominance Missile Meteor. After he had held the Technical Director position of Bayern-Chemie GmbH (a subsidiary of MBDA Missile Systems) for 18 years, Mr Besser still works as the company's senior consultant today. He has been a member NATO STO's AVT Panel member since 1998, and is currently its chairman. He received two Panel Excellence Awards for his service.

Dr.-Ing. Dennis Göge

started his career at the German Aerospace Center (DLR) in 2000 as Research Scientist. In 2005 he became Deputy Department Head and Head of a Research Group at DLR in Göttingen, Germany. In 2007, he then joined the NATO STO in Neuilly-sur-Seine, France, as Executive Officer. In 2010, Dr Göge has been appointed Executive Board Representative and Program Coordinator Defence and Security Research at the DLR in Cologne, Germany. Actually, Dr. Göge is representing DLR in various national and international supervisory bodies, advisory councils and committees. He is Member of the NATO Science and Technology Board (STB) and former Chairman of the NATO STO AVT Panel In addition, he is an advisor to the German Federal Ministry of Defence and to the Federal Ministry for Economic Affairs and Energy.

Mr Michael Huggins

started his engineer career with Rockwell International in 1985, and joined the United States Air Force Rocket Propulsion Laboratory in 1987. From 1993–94, he served as the Deputy Director of the Phillips Laboratory Propulsion Engineering Division overseeing development projects for space access, missile defence propulsion, and the beginning of the technology research for USAF ICBM strategic sustainment initiative. Since 1997, Mr Huggins has worked in several positions at the Air Force Research Laboratory (AFRL), responsible for the micro and nano-satellite technology roadmap, and directing exploratory research and development programs related to advanced missile, rocket, and spacecraft propulsion. Currently, Mr Huggins is technical counsellor to the Director on Systems Engineering and Programmatic Matters. He leads 'systems of systems' concept developments across the AFRL directorate's divisions and outside agencies for various air and space platforms.

Mr Alan Shaffer

serves as the Director, NATO STO Collaboration Support Office in Neuilly-sur-Seine, France, coordinating a network of about 5000 scientists across NATO and partner nations. He previously served as the US Principal Deputy Assistant Secretary of Defense for Research and Engineering, from 2007–2015. Serving twice as the acting Secretary, he was responsible for all aspects of the $ 25 billion research and engineering program. He also held numerous special assignments, including the (acting) First Director, Operational Energy, Plans and Programs, and was Executive Director of the US DoD Energy Security and Mine Resistant Ambush Protection (MRAP) Task Forces. Mr Shaffer also served a 24-year United States Air Force career. He was awarded the DoD Distinguished Executive Presidential Rank Award in 2007 and 2015 and the Meritorious Rank Award in 2004.

Dr.-Ing. Dirk Zimper

joined the German Air Force in 2004 and holds a doctoral degree in Aerospace Engineering from the German Armed Forces University Munich. Professionally trained as an ammunition specialist, he commanded a specialized maintenance unit for aerial missile systems and pyrotechnic aircraft ammunitions. Besides his service as an air force officer, he worked as Research Scientist in defence related projects of the German Aerospace Center (DLR). From 2013 to 2016 he served as Executive Officer for the Applied Vehicle Technology Panel at the NATO Science and Technology Organization. In early 2017, Dr. Zimper was appointed as Head of Defence Research at the DLR's overall Program Coordination for Defence and Security Research.

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Future Battlefield Rotorcraft Capability

Operating in the Land and Littoral Environment Anno 2035

Part 1: Analysing the Future Operating Environment

By Lieutenant Colonel Wim Schoepen, BEL AF, JAPCC

This topic was the subject of an essay paper the author recently wrote under supervision of the University of Lincoln, UK. For the purpose of publication in this journal, the essay has been divided into three parts split over this and the two following issues. An overall introduction to the topic was published in Journal 23.[1]

The operating environment is changing at an exponential rate, forcing NATO to come up with innovative solutions to successfully confront an ever-larger array of challenges, threats and potential adversaries. Multiple recent strategic analysis reports [2,3,4] have given the political and military leadership of the Alliance insight into what those challenges, threats, and potential adversaries might look like and how they might affect the Alliance's ability to effectively and efficiently conduct its operations twenty years from now.

The very difficult process of translating all of this into tangible solutions, in the form of abilities and ultimately capabilities at the tactical level from 2035 and beyond, has only just started. The aim of this series of articles is to provide insights into how the operating environment of 2035 and beyond could shape the Future Battlefield Rotorcraft Capability (FBRC) in support of NATO forces operating in the land and littoral environments. Although it is today virtually impossible to define the total set of requirements and characteristics of the different rotorcraft[5] that ultimately will be at the heart of this new capability, it is worthwhile investigating how the future operating environment, including anticipated technological developments, as well as the potential requirements emanating from the direct users of this new capability are likely to shape the next generation of rotorcraft and their associated organic units.

In this first of three articles, the most defining factors of the future operating environment, as determined in strategic reports as well as technological research reports, will be analysed and evaluated for their direct potential impact on the shaping of the FBRC. These factors will be primarily technological in nature and will consequently define the technological characteristics of the platforms that will eventually constitute the new capability.

The Rise of the Megacity

The future operating environment will be shaped by climate change, overall scarcity of resources, and technological development and exacerbated by the pervasive effects of globalisation. It will therefore be characterized by unprecedented levels of risk and uncertainty, bringing the currently used but ever enduring descriptors 'Congested, Cluttered, Contested, Connected, and Constrained'[6] to a whole new level. Indeed, the dynamics of warfare in a 2040 megacity, which counts 30 to 50 million inhabitants, can by no means be compared to any kind of fight in Built-Up Areas the Alliance has undertaken so far. It is not only the sheer size of this future Area of Operations (AoO) that will dramatically change the way of conducting operations, but even more so the very complex multi-layered and multi-faceted environment the megacity will generate and potentially offer to future adversaries. Even more than was the case in the past decades, adversaries will use the 'advantages' megacities have to offer in pursuit of their objectives. With some notable exceptions, every kind of successful warfare has been asymmetric in nature and there would be no better place than the future metropolis to exploit asymmetric Tactics, Techniques, and Procedures to the fullest. For any Alliance Task Force, it would be virtually impossible to physically seal off such an AoO and consequently guarantee complete or even sufficient freedom of movement for its own troops. Likewise, it would become impossible to control the information domain, which is so critical in the build-up of Situational Awareness (SA) and in any decision-making process. Finally, it would demand a disproportional amount of effort to even try to effectively manage the potential flux of goods and people in those parts of a megacity where governmental control has ceased to exist. But the truth is that NATO will not have a choice. This AoO will be forced upon the Alliance, especially by those adversaries who cannot match NATO's capabilities in less congested environments.

Threat Proliferation

Furthermore, NATO acknowledges its technological superiority will be challenged, and consequently, it will need to develop abilities to counter a wide range of proliferating threats posed by the rising capabilities of near-peer or peer potential adversaries.[7] These threats can either be kinetic or non-kinetic in nature, but both will have the potential to destroy rotorcraft or at least seriously degrade their performance to an extent that could lead to mission failure. Considering the fact that rotorcraft, due to the very nature of their employment, are forced to operate close to the ground, they will be exposed to a plethora of kinetic weapons and weapon-systems ranging from Small Arms Fire (SAF) and Rocket Propelled Grenades (RPGs) to Anti-Air Artillery (AAA) to MAN Portable Air Defence Systems (MANPADS) and Surface-to-Air Missiles (SAMs). In addition, they might be engaged by Directed Energy Weapons (DEWs) such as high-powered lasers and microwave emitters. They might also be exposed to less kinetic but equally lethal attacks with Chemical, Biological, Radiological, or Nuclear (CBRN) weapons, putting the crews and passengers at risk. Finally, they will be forced to operate in a highly contested electromagnetic environment in which FBRC units and platforms could become the targets of deliberate electronic attack. The effects of these electronic attacks could range from disturbing but manageable interferences to the communications and navigation systems up to a near-complete loss of SA.

Resulting Technological Requirements for the FBRC

To survive and operate in this immensely hostile environment, every single rotorcraft will need to be equipped with a combination of passive and active defensive systems incorporated in a purely military platform design aimed at maximum autonomy and survivability. As far as maximum autonomy is concerned, every design should cater for redundant communication and navigation systems allowing the crews to continue their mission even when the Global Positioning System (GPS) is no longer available, either temporarily or indefinitely, or when the on-board flight and mission management systems are no longer able to connect to a central network. Furthermore, to guarantee maximum survivability, the design of every rotorcraft should allow its crews to operate in a CBRN contaminated environment, ideally without the necessity to wear special protective clothing and with the ability to easily decontaminate the rotorcraft itself at the end of the mission.

In the same way, every rotorcraft should be equipped with a state-of-the-art and fully autonomous 'Defensive Aids Suite' (DAS) providing the capability to detect threats at a very early stage and eliminate them by either non-kinetic or kinetic means.

Integrated high-energy laser weapons may be required for a FBRC.

This DAS should therefore incorporate high-definition sensors able to detect threats based on their infra-red or electro-magnetic signature as well as jammers preventing the rotorcraft from being tracked, locked, and engaged by actively emitting weapon systems. In addition to the classic chaff and flare dispensers, the DAS should equally incorporate defensive systems such as decoys and low energy lasers, able to either prevent missiles from being fired, deflect them from their intended target, or destroy them altogether. Finally, this DAS should be equipped with a fully automated, on-board weapon system able to physically destroy or at least suppress most of the threats and to defeat terminal larger-size projectiles and missiles. The armament of this on-board weapon system should be based on a gun or canon but could also be complemented with guided rockets and fire-and-forget missiles.

Additionally, the rotorcraft should be able to take the proverbial beating. Although it would be virtually impossible to survive all types of kinetic impacts, especially those coming from weapon systems such as RPGs, MANPADS and SAMs designed to defeat large or heavily armoured targets, the future battlefield rotorcraft should be able to survive being hit by SAF, light AAA and even some DEWs. This means vital parts of the rotorcraft should receive robust anti-ballistic protection against kinetic impacts, but also essential systems or subsystems should be doubled so that the rotorcraft can continue its mission, or at least return safely home, in the event of being hit.

An artist concept of the Aerial Reconfigurable Embedded System (ARES), a compact, high-speed and highly-automated delivery system with vertical take-off and landing (VTOL) capabilities.

'Today still in its infancy, the unmanned rotorcraft, either in the form of a Remotely Piloted Rotorcraft, robot or hybrid mix, will become an integral part of the FBRC.'

The physical environment will equally do its part of the shaping. Next to the fact that the FBRC will need to be able to operate in a littoral, hence salty, environment, the current requirements with regard to 'Hot & High' will also endure. Specific attention will have to be paid to the particular dangers the future physical operating environment will pose to crews and rotorcraft. Consequentially, fully automated take-offs, approaches, and landings should be made possible to mitigate the very detrimental effects of 'brownout' and, albeit to a lesser degree, 'whiteout'. In addition, to facilitate operations in the very complex three-dimensional battlespace, the rotorcraft will need to be equipped with sensors and devices to avoid collision with natural as well as artificial obstacles but also with other users of the third dimension that are likely to significantly increase in numbers.

The Emergence of Autonomous RPA Systems

Current and future technological developments will not only contribute to an increased and diversified threat. They will also provide the FBRC with solutions to counter them as well as with innovative ways to accomplish its future missions. One of the most obvious technologies expected to considerably influence the future operating environment will be that of the ubiquitous robot.[8] In addition to the existing Remotely Piloted Aircraft (RPA), we may witness the advent of fully autonomous weapon systems able to select and engage targets without human intervention. Both weapon systems are likely to come in two forms. At one end of the spectrum, we are likely to see the development of high-end, highly sophisticated RPAs with extended loiter times and a variety of sensors and weapons aimed at dominating the operating environment. Upon request and within a customer-and-provider relationship, they will be able to temporarily team up with the rotorcraft and provide it with complementary – and often superior – sensing and shooting capabilities. At the other end of the spectrum, we will see the emergence of swarms of low-cost, single-use, and expendable robots, launched by either an RPA or by the rotorcraft themselves, aimed at the degradation or even destruction of enemy offensive and defensive systems. In conclusion, both the RPA and the robot will provide the FBRC with the ability to not only detect and defeat threats at an early stage but also to execute missions more effectively and more safely.

But in what form will these RPAs and robots come? Similar to the next generation of the fixed wing RPA, the remotely piloted rotorcraft will also undergo a dramatic evolution. Their unique characteristics will provide commanders with tactical as well as logistic solutions that simply cannot be provided by other assets if not at unacceptable costs in terms of risks to crews and assets as well as availability. Especially for routine or emergency re-supply missions, the unmanned rotorcraft has a bright future ahead of itself.[9]

Conclusions and Outlook

As militaries begin to consider the future of FBRC, it is clear technology will have a huge role to play. In conclusion, three themes must be considered during future capability development:

Purely Military Design. Only a purely military design will allow for the effective and efficient integration of the full range of protective equipment that would allow the rotorcraft to survive to operate. Therefore, even more than today, there will be no longer a place within the FBRC for those contemporary helicopter types that are merely militarized versions of an existing civilian model. Today these models are mostly found in the different fleets of Light Utility Helicopters, such as the A-109 or the UH-72.

Considerable Cost. The FBRC will come at a considerable cost with regard to overall added weight, space on and within the rotorcraft and, obviously, financial resources.

Hybrid Nature. The FBRC will be hybrid by nature. It will consist of both manned and unmanned platforms that can either operate autonomously or in concert with remote piloting. As such the FBRC will make optimum use of technology to execute its full range of missions in the most effective, efficient and safe way possible.

In the second article, a similar analysis will evaluate the FBRC's clients' to-be-expected requirements that will ultimately shape the new capability not only in terms of platform characteristics such as size and cargo capacity, but also in terms of quantity and organisational structure. The third article will attempt to describe the whole FBRC following the DOTMLPFI[10] methodology as defined by NATO Allied Command Transformation. ●

1. Miklos Szabo, 'The Future NATO Rotorcraft Force'. In JAPCC Journal Edition 23, 2016. P. 57–61.
2. NATO (SACT) (2013) Strategic Foresight Analysis 2013 Report. Norfolk, Virginia USA: NATO Headquarters Supreme Allied Command Transformation.
3. NATO (SACT) (2015) Strategic Foresight Analysis 2015 Interim Update to the SFA 2013 Report. Norfolk, Virginia USA: NATO Headquarters Supreme Allied Command Transformation.
4. Ministry of Defence (2014) Strategic Trends Programme, Global Strategic Trends – Out to 2045, Fifth Edition. London, UK: Ministry of Defence.
5. Within the context of these articles, the term rotorcraft will cover all types of aircraft that have helicopter-like flight profiles regardless of the lift and propulsion system they use. Consequently all types of contemporary lift and propulsion systems such as single rotor helicopters (e.g.: UH-60), twin counter-rotating intermeshing rotor helicopters (e.g.: K-MAX), twin counter-rotating co-axial rotor helicopters (e.g.: Ka-52) or counter-rotating tandem rotor helicopters (e.g.: CH-47) as well as tilt rotors (e.g.: MV-22) or any kind of future types of propulsion that are yet to be developed fit this description.
6. Ministry of Defence (2015), Strategic Trends Programme, Future Operating Environment 2035, First Edition. London, UK: Ministry of Defence.
7. NATO (SACEUR & SACT) (2015), Framework for Future Alliance Operations. Norfolk, Virginia USA: NATO Headquarters Supreme Allied Command Transformation.
8. Kott, A., Alberts, D., Zalman, A., Shakarian, P., Maymi, F., Wang, C. and Qu,G. (2015), Visualizing the Tactical Ground battlefield in the Year 2050: Workshop Report. Adelphi, Maryland USA: US Army Research Laboratory.
9. Van de Ven, E. (2014), Unmanned Cargo Aircraft. JAPCC Journal, Ed 19, 73–77.
10. Doctrine, Organisation, Training, Material, Leadership, Personnel, Facilities and Interoperability.

Lieutenant Colonel (GS) Wim Schoepen

joined the Belgian Defence in 1990 after having completed his academic studies at the Royal Military Academy. He received his helicopter pilot wings in 1992, became an instructor pilot in 1996 and accumulated more than 3.000 hours through different assignments in training units and operational squadrons. His operational experience started in 2000 with operation KFOR and has grown over the years with multiple EUBG, NRF and VJTF commitments. Additional staff and academic assignments have given him a solid background in education, training, operations, doctrine, and policy. He also has a keen interest in strategic security and defence issues. He joined the JAPCC in 2016 as a Subject Matter Expert on Helicopter Operations.

Preserving NATO's C2 Edge

Capitalizing on MTDS/LVC Advanced Capabilities

By Major Jay Vizcarra, USA AF, NATO E-3A

Introduction

Mission Training through Distributed Simulation (MTDS) began in the late 1990s as an internal training system, and through the work of the NATO E-3A Airborne Warning and Control System (AWACS) Component, it is now a significant model for simulating various military capabilities in team play throughout NATO. In the last two years, MTDS has rapidly expanded to support interoperability with a number of airframes, nations, weapon systems, and even Joint Intelligence, Surveillance, and Reconnaissance (JISR) capabilities. More recently and significantly, integration with the Distributed Training Operations Centre (DTOC) enabled E-3A international operators to benefit from customized daily training with multiple weapon systems worldwide.

As resources continue to shrink, these advancements in E-3A's MTDS within the Live, Virtual, and Constructive (LVC) training environment have ensured E-3A maintains its leading edge in producing and maintaining combat mission ready personnel while strengthening Tactics, Techniques, and Procedures (TTPs) within the Alliance. MTDS capabilities have generated monumental advantages for the NATO Airborne Early Warning and Control (NAEW&C) Force and could be applied to other NATO weapon systems. As NATO enhances its forward presence to deter possible adversaries, it must seek to expand its current training regime to prepare for an environment where the growth of asymmetric threats potentially outpaces our ability to field advanced capabilities. The LVC domain presents the opportunity to balance this inequity with effective, low-cost solutions.

E-3A's Rapid MTDS Evolution

In 2014, the E-3A MTDS demonstrated a distinct capability during Exercise VIRTUAL MAGIC to share Command and Control (C2) data in a simulated joint operation scenario with E-3D combat mission ready crews in RAF Waddington, UK.[1] VIRTUAL MAGIC validated NAEW&C Force's ability to connect with geographically separated participants in a distributed environment, while sparking further operational needs to explore and procure additional simulator advancements.

After numerous successes in distributed events transpired in 2015, MTDS surpassed many senior leaders' expectations. It demonstrated reliable connectivity and beneficial training with multiple external MTDS equivalent systems spanning Dutch and Belgian F-16s, German Eurofighters, Canadian F-18s, US Control and Reporting Centres (CRCs), Polygon Electronic Warfare Ranges and interoperability with the Warrior Preparation Centre (WPC) located in Einsiedlerhof, Germany. WPC integration, via the Combined Federated Battle Laboratories Net (CFBL-Net), enabled the E-3A to tap into larger bi-annual distributed events such as Exercise SPARTAN WARRIOR and SPARTAN ALLIANCE where vital training with Joint Tactical Air Controllers (JTACs) and CRCs is gained from a wide range of operational scenarios. Such distributed events are approved through HQ Supreme Allied Commander Transformation (SACT), under Chapter IV of the NATO Military Education and Training Program (MTEP), and are open to all NATO allies.[2,3]

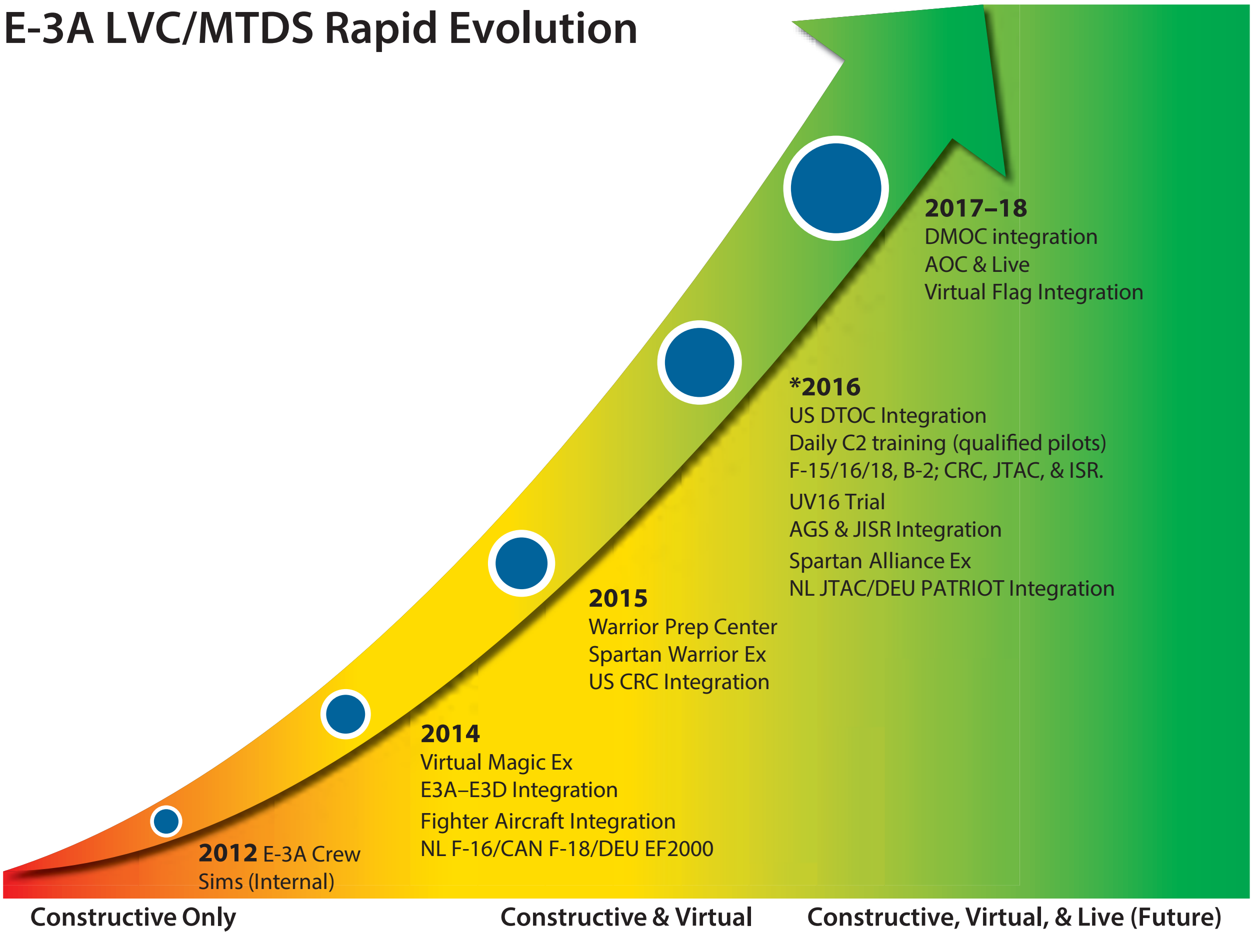
In 2016, the E-3A MTDS demonstrated tremendous interoperability growth adding support to PATRIOT missile batteries in NATO Integrated Air & Missile

NATO E-3A takes-off from Forward Operating Base (FOB) Konya Turkey.

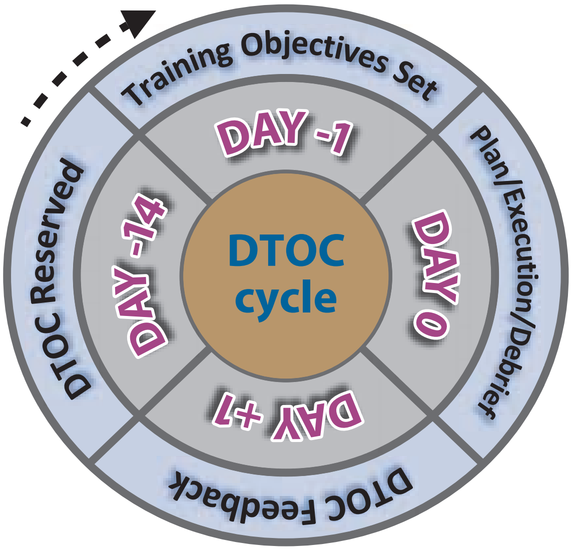
Defence (IAMD) scenarios and Counter-Daesh scenarios for E-3A crew deployment spin-up. New milestones were also achieved in additional distributed events such as UNIFIED VISION 2016 (UV16), a trial that integrated emerging JISR capabilities. For the first time, E-3A and AGS systems proved the ability to fuse Battle Management Command and Control (BMC2) and JISR layers in a sensor-to-shooter construct. The crews supported joint time-sensitive targeting operations while providing situational awareness to operational level commands and feeding ISR results to Federated Process, Exploitation, and Dissemination (Fed PED) nodes.[4] UV16 provided the Force with many proof-of-concept successes, which propelled future E-3A requirements for increased interoperability, data-sharing, and new potential Coalition Server Database (CSD) capabilities. Furthermore, with regards to E-3A and AGS integration (NATO's two organic airborne platforms in the near future), operators from both weapon systems were able to capture TTPs two years ahead of AGS air vehicle delivery.

The numerous MTDS improvements mentioned so far have brought substantial training value to the NAEW&C Force and E-3A operators. However, recent integration with the DTOC, located in Des Moines, USA, under the 132nd Fighter Wing, Air National Guard, has proven to be the most significant advancement to date, enabling realistic, high-quality, and near-real time C2 training. DTOC distributed operations are considerably robust involving multiple fighter aircraft variants with qualified pilots in a complex threat environment, supporting a large amount of tailorable scenarios and catering to specific E-3A objectives. In addition, this training opportunity is available on a daily basis for a fraction of the cost of a live E-3A operational sortie.

E-3A LVC/MTDS Rapid Evolution



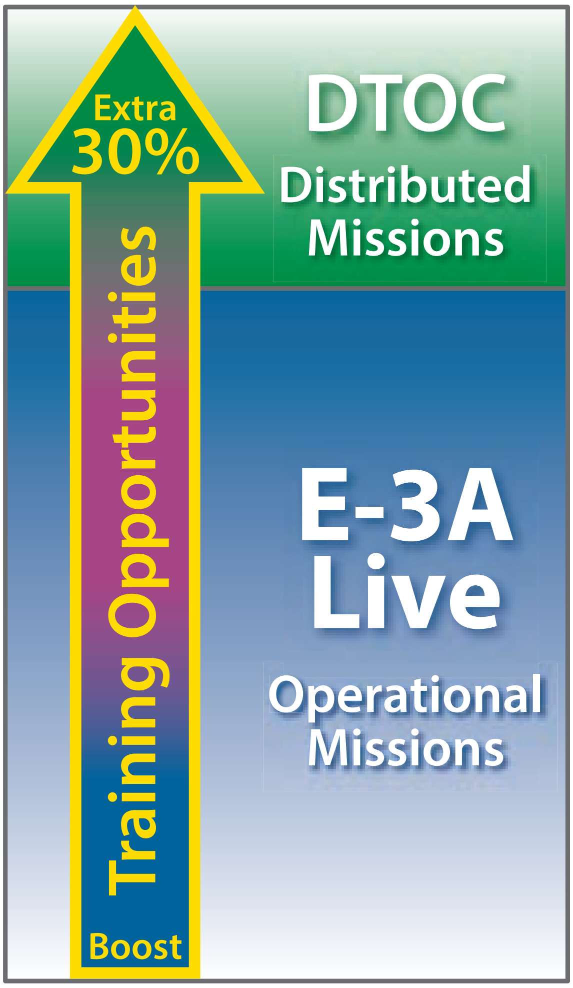
*Significant year of interoperability growth

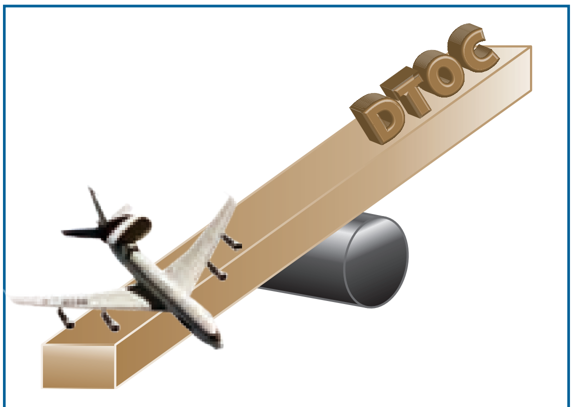


Stepping Into a DTOC Mission

A DTOC mission cycle normally commences with a formal reservation two weeks prior. On the day before the event, operational scenarios, training objectives, and requirements are formally coordinated with DTOC, which reconfigures the simulation for that particular mission. On the morning of execution day, all players receive mission planning products and plan for the specified scenario. Crew coordination is conducted on typical mission essential items such as airspace, communication plans, C2 procedures, data links, surveillance and identification plans, fighter C2 contracts, and implementation of electronic support measures, while instructors and simulator contractors coordinate white force injects. The DTOC event then executes in the afternoon followed by a comprehensive debrief session. On the following day, the participating crew provides a Post Mission Simulation Report with any relevant feedback to improve scenario events, training, or processes to DTOC.

In the short span of a DTOC mission cycle (DAY-1 thru DAY+1), E-3A and DTOC personnel are consistently communicating and coordinating the event to ensure training effectiveness. This allows the flexibility to not only tailor the mission to meet the crew's needs but also to ensure critical feedback is captured and implemented to improve future DTOC missions. Additionally, given the large number of event script combinations, nearly any training objective can be met from multiple tactical level C2 scenarios to larger operations involving ISR in any desirable world region. Another significant advantage of a DTOC event is the ability to halt the mission at any point to conduct short debriefs, which is not normally found during live training. Sharing lessons learned real-time, during a 'paused mission' debrief, mitigates operator error repetition, provides a higher probability of retaining knowledge, and eliminates the potential for the critical topic to be missed during a post-mission debrief. With an arsenal of qualified pilots and operators from multiple weapon systems, including F-15/16/18, B-2, CRC, RC-135, MQ-1, AWACS, Army Fires Support, JTAC, and the AF Distributed Common Ground System (DCGS) in the DTOC, NATO E-3A operators receive high-quality training and invaluable joint operational knowledge, which ignites further development of TTPs among its participants.





Distributed Training Cost Benefits.

Quantifying DTOC Training Value

Given the daily availability and increased training opportunities DTOC provides, it has become a force multiplier for the E-3A Force while ensuring aircrew preserve their operational proficiency and skill sets in their respective and qualified positions. Annually, as a whole, mission crewmembers are required to execute approximately 8000 live flights and simulations combined. DTOC missions deliver a significant amount of training value to the Force with an additional 2400 missions. When compared to E-3A operational live flights, this equates to an increase in training opportunities by 30 percent across the entire Force.

It is important to note that while some crew positions may benefit from 'real-world' E-3A operations, such as the E-3A surveillance section supporting Assurance Measures (which is purely of a surveillance nature), other crewmembers, such as E-3A weapons controllers, may often experience limited training opportunities. Therefore, during these particular operational sorties, there is an apparent lack of effective and meaningful training. In turn, having daily DTOC missions at the E-3A force's disposal mitigates such training losses and provides operators a guaranteed 100 percent in training value. Furthermore, with unfortunate reductions in personnel as well as flying hours due to decreasing aircraft availability, increased DTOC usage will undeniably continue to fill an obvious training void where needed. Finally, with regards to the organization's budget, the cost of running a


Sunrise at NATO Air Base Geilenkirchen.

DTOC training event is only a fraction of the cost of generating a live E-3A sortie. With substantial cost savings, DTOC capability is an obvious long-term and worthwhile low-cost solution.

Future Expansion Toward a Complete LVC

While integration with DTOC has proven to be a huge leap forward in E-3A training opportunities, expansion to support a more multifaceted MTDS/LVC capability at the NAEW&C Force are already underway. One particular venture will deliver connectivity with US Air Combat Command's Distributed Mission Operations Centre (DMOC) in Kirtland Air Force Base. Such integration will further training and capabilities to allow the E-3A force to participate in larger, operational level exercises such as VIRTUAL FLAG. These quarterly 'RED FLAG'-type simulation events involve worldwide coalition participants and higher C2 levels such as an Air Operations Centre or Joint Force Air Component Commander supporting a wartime scenario with full Air Tasking Order cycles and other applicable operational directives.[5] VIRTUAL FLAG exercises can replicate full-scale joint or coalition operations, within any Major Command, in any land or maritime environment. Given the reality of limited training opportunities during current E-3A operations, E-3A participation in distributed exercises like VIRTUAL FLAG would further ensure the Force remains at the C2 leading edge and sustains its ability to rapidly support future NATO and SACEUR directives.

Conclusion

The adoption and advancement of MTDS/LVC capabilities have undisputedly provided substantial training value and cost benefits to the E-3A Force. Such capabilities enable the Force to move toward a 'larger interoperability end state where service and joint integrated LVC training systems are routinely interconnected to support joint training and mission rehearsal events.'[6,7] Distributed events, like DTOC missions, are now the 'new norm' in the Force's training culture and continue to mitigate training deficiencies stemming from reduced aircraft availability and potentially limited training value with ongoing operations. As many NATO units face parallel training deficiencies resulting from comparable limitations, it is imperative they also strive to adopt similar distributed capabilities. Tapping into such networks would undoubtedly boost training opportunities, strengthen TTPs within the Alliance, and ensure our war fighters preserve their superior edge in tomorrow's potential conflicts.

1. Lt Col MacLean, Alexander S., 'Exercise Virtual Magic,' In The Journal of the JAPCC, Edition 20 (2015): p. 28–31.
2. BI-SC Collective Training and Exercise Directive (CT&ED) 075-003, 2 Oct. 2013.
3. Halldale Group, 'An Evolving Education & Training System,' Military Simulation & Training Magazine, Issue 2, 2013: p. 14–16.
4. Tim, Fish, 'Farnborough 2016: NATO AGS operators get hands on,' [online article], 6 Jul. 2016. Available from https://www.shephardmedia.com/news/uv-online/farnborough-2016-nato-ags-operators-get-hands/.
5. Lt Col Drechsler, Don, 'Distributed Mission Operations', [briefing], 2006. Available from www.dtic.mil/ndia/2006psa_psts/drex.pdf.
6. Office of the Under Secretary of Defense, Personnel & Readiness, Training Transformation Implementation Plan, 10 Jun. 2003.
7. Lollar, G., & Hambleton, O., 'USAF Distributed Mission Operations (DMO), NATO M&S Group Conf, RTO-MP-MSG-035, 2005.

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earned his commission through Officers Training School in 2004. His unique operational and test experience includes the E-8C, RQ-4, and E-3A weapon systems. He is a Senior Air Battle Manager and possesses qualifications as an Instructor Weapons Controller, Instructor Surveillance Controller, and Fighter Allocator. During his previous assignment, as Global Hawk Test Lead, he was responsible for the initial stand-up of combat operations for the RQ-4 Block 40 in CENTCOM and AFRICOM. Currently, he is an Instructor Passive Controller and Chief of Training Development for Electronic Warfare, Operations Wing, E-3A Component, NATO Airborne Early Warning & Control Force. He is an advocate for C2 & ISR interoperability and accredited with recent E-3A integration with the U.S. Rivet Joint, Global Hawk, NATO CRC, and NATO AGS.

Better Together

First Ever Air-to-Air Refuelling Clearance Request/Approval Training and Table Top Exercise

By Major Victoria Thomas, USA AF, JAPCC

'Because we live in times with new security threats, with instability, and we don't need more instability. We don't need less cooperation in Europe; we need more.'
NATO Secretary General Jens Stoltenberg[1]

Introduction

In July 2016, NATO and the European Union (EU) leaders signed a Joint Declaration solidifying their commitment to greater collaboration and asserting information sharing, asset interoperability, and more integrated exercise and training programmes would help the two organizations address current and future threats.[2] In December 2016 the respective Councils endorsed a common set of proposals on the implementation of the joint declaration, which underlined NATO and EU nations' engagement to improve military capacity and capability building in concert to preserve their military vigour and cope with future challenges. In general terms, NATO and the EU address capacity with procurement and capability with interoperability programmes by preference through cooperation.

An Airbus A330 MRTT refuels an A400M. European Nations have formally begun acquiring an AAR capability under the MRTT Fleet project.

In the field of Air-to-Air Refuelling (AAR), European nations have 'formally begun the acquisition process for a new aerial refuelling capability under the [A330] Multinational Multi-Role Tanker Transport (MRTT) Fleet (MMF) project.[3] Other procurement programmes for tanker aircraft including A400M are also underway. However, if NATO and the EU do not ensure tanker and receiver assets are interoperable, the capacity building investment will not be exploited to the fullest. Therefore, the first step in turning AAR capacities into capabilities is ensuring the tanker and receiver nations have issued a bilateral clearance to conduct refuelling. A bilateral clearance is granted when both nations have reviewed the technical and operational compatibility, crew training and currency, the level of maintenance ensured by the other nation, and made the appropriate legal and fiscal arrangements. In 2014, NATO adopted these issues as the Five Pillars of an AAR Clearance (see Figure 1).

In 2016, the Alliance furthermore issued the Guide to Obtaining AAR Clearances and Compatibility Certification. The guide is not mandatory but represents the only given NATO clearance process overview. Depending on the nation, the authority to permit an AAR activity via a clearance is delegated to different agencies. No matter who those agencies are, they should ensure that all pillars between a tanker and receiver pair have been addressed before granting a clearance.

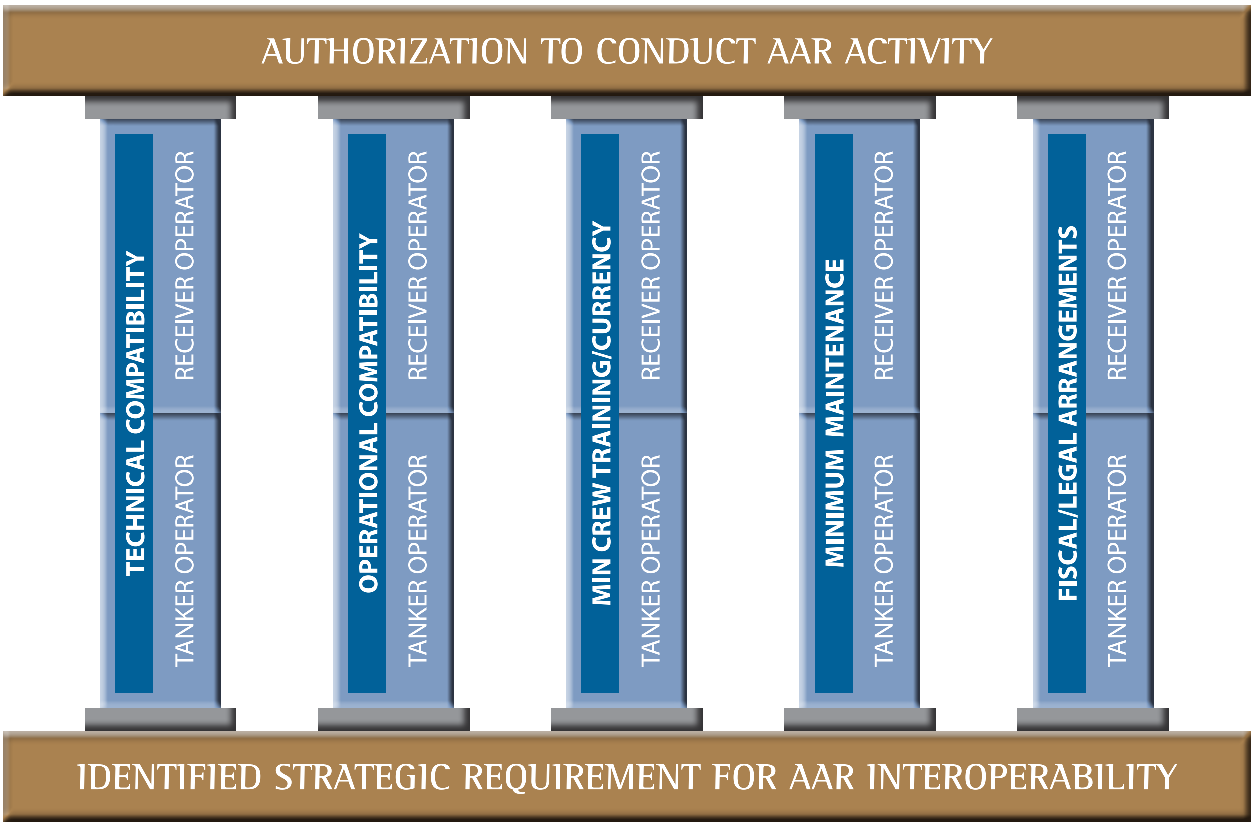
While the Pillars easily present what should be reviewed in the clearance process, they do not explain how it should be accomplished. Until recently, no NATO or EU training existed to cover this subject. Therefore, the JAPCC developed the first-ever training and exercise event dedicated to the clearance process to continue increasing NATO and coalition interoperability in AAR operations.

The AAR Clearance/Approval Training and Exercise Concept

In January 2017, the JAPCC led a team of six agencies in conducting and hosting the first iteration of the 'NATO and EU AAR Clearance Request/Approval Training and Table Top Exercise (TTE)'. Immediately after the JAPCC Executive Director approved the idea, the European Defence Agency (EDA) and the NATO International Staff – Defence Investment Division – (NATO IS/DI) agreed to support the effort within the frame of their ongoing activities on AAR. The Movement Coordination Centre Europe (MCCE) and the Dutch Flight Test Centre dedicated facilitators while the European Air Transport Command (EATC) offered to host the event.

The JAPCC-led team conducted nine months of planning prior to this first training event. Nothing like this had ever been done, and if the TTE missed the mark, it could have negatively affected global momentum in this critical area. The team decided on a

Figure 1: The Five Pillars of an ARR Clearance.



three-day programme open to any EU or NATO entity with a tie to AAR. By casting the net wide, facilitators created an unprecedented opportunity for test personnel and government representatives to learn about and apply the clearance process alongside operators, industry, and planners. Eventually, the level of participation was beyond expectation with 74 personnel from 16 EU and/or NATO nations, 40 organizations, and two industry partners attending.

Problem Identification and Education

During the first two days of the event, facilitators from JAPCC, MCCE, and Dutch Test Centre brought all participants to the same level of understanding about the AAR clearance process by instructing and leading discussion on the NATO Defence Planning Process, the Five Pillars, and NATO-led operations that have highlighted the need for a TTE. Several lectures laid the fundamental knowledge about the AAR clearance request and verification processes including current NATO and national AAR directives and methods as well as the ones in development.

On Day 1, the Dutch Flight Test Centre hosted a seminar specifically designed for test and airworthiness personnel but open to subject matter experts representing any of the above mentioned Five Pillars. A Dutch test pilot facilitated discussion between military and industry personnel on challenges currently elongating AAR testing, one of which is the reluctance to share data. Therefore, since 2016, there has been a campaign supported by NATO IS/DI and EDA to create a data cross-recognition programme. This would allow nations to bypass costly technical data assessments and cumbersome sharing protocols by accepting the work of other test centres whose personnel have been specifically trained and certified at an agreed minimum standard. It would not only save human and financial resources but could ensure nations do not rely on something called a Category I, or 'Urgent Need' Clearance, which requires no testing and has the potential to put crews in a much riskier situation while refuelling. Attendees were supportive of the campaign and interested to get involved as NATO and the EU develop it further.

Leading into the training event's exercise portion, the TTE participants were introduced to an on-going real world clearance dilemma. An AAR planner from MCCE explained that while over a dozen nations had committed tanker and/or receiver assets for the 2017 European Air Refuelling Training and ARCTIC CHALLENGE Exercise), many questions still remained about who would be able to refuel with whom. The presentation highlighted that failures in the clearance process are most recognizable during planning. Only at this stage is it evident which pillars of a clearance have not been addressed. This can lead to hasty Urgent Need Category I clearances or can result in mission cancellation – not an ideal scenario for commanders, planners, or operators.

TTE Scenarios, Lessons Identified, and Key Takeaways

In order to continue cross-pillar collaboration and build upon the first two days, TTE facilitators built ten clearance request scenarios. Students were assigned to teams of six varied by nationality and expertise and tasked with assessing whether or not a tanker and receiver pair in each scenario were capable of conducting AAR operations. The teams answered questions that specifically led them through the AAR process, NATO and national directives, and the JAPCC AAR matrix. Facilitators floated between teams to review solutions, discuss alternative outcomes, and assign the next scenario. Every team investigated at least

© Credit to EATC

Major General Christian Badia, EATC Commander, addresses the training audience.

three pairs. The scenarios enabled instruction on a standardized process, while allowing participants to experience known significant gaps of the AAR clearance process. The following lessons and key takeaways were particularly identified.

Simple mistakes. Several scenarios included requests for receivers to refuel with either technically or politically incompatible tankers. This ensured students learned the importance of knowing the capabilities of assets available and were particular about analysing requests and source documents. Simple mistakes due to lack of inventory knowledge or lack of AAR clearance verification experience in general, can have large repercussions such as nations committing assets that are not useable with other committed assets, or a complete scrap of an AAR plan.

Data sharing hurdles. As previously discussed, the cost of air refuelling asset data collection, over-classification of information, and commercial proprietary rules can be incompatible with national budgets and refuelling request timelines. Until the data cross-recognition programme is in place, nations use either their own data assessments or what is called a 'read across' in which Nation A's previously collected data is verified, rather than collected again, by Nation B. A few scenarios led students through pairs that had no technical assessment completed, but because of the specific nations in the scenario, perhaps a read-across was possible.

Lacking document and terminology standards. Prior to 2013, the NATO doctrine covering AAR operations (ATP 3.3.4.2) contained national annexes which were populated with asset data, clearance information, contact information and operational specifics. Those annexes were removed from the ATP in favour of nationally maintained Standards Related Documents (SRD) which supplement the ATP. This concept allows nations to update their respective supplements without the requirement for ratification by all NATO nations. However, this decentralized control led to a lack of standardization in both document structure and terminology which increases the time needed to verify if a clearance exists or how to go about procuring one. To help solve this issue, the JAPCC created a national SRD template which has been posted to its website since early 2016, but only a few nations have adopted the layout. JAPCC is also conducting an informal study about the feasibility of implementing an online standardized SRD questionnaire for nations to populate themselves. The questionnaire could possibly also auto-populate the JAPCC AAR Compatibility and Clearance Matrix'[4] and thus provide an effective community-wide solution that would ensure national fidelity while avoiding unnecessary duplication of effort.

Missing SRDs. TTE participants discovered that several NATO/EU nations possessing an AAR capacity have not published an SRD at all.[5] This is especially true for the ten European receiver only nations, for which only two had previously filed an SRD. However, these two SRDs contained little more than contact information, which is arguably a good start but more work needs to be done to create a useful document. After the TTE, one of these two nations has since improved its SRD with more complete data. Other nations recently contacted the JAPCC about creating their first SRD. The JAPCC will continue to support this trend.

Significance of consolidated clearance offices. Most, but not all, nations have one centralized office that assess whether or not the Five Pillars have been addressed for their assets. This office then reports those clearances in their SRD or submits official declarations to the JAPCC for input on the AAR Matrix. Those that do not have a consolidated office, create a great deal of uncertainty for their own commanders and operators, and even more for those of other nations.

Cross-pillar awareness. The TTE proved itself when a test engineer with decades of experience remarked he previously had little awareness how his assessments were used once they left his desk. This newly gained understanding would now inform his work to make clearances easier as they move towards the planning phase. Furthermore, participants from several nations found information they assumed available in their national documents was in fact missing. Through the TTE they were able to experience how a failure to ensure complete and accurate reporting affected an asset's AAR capability.

To help highlight which nations have which clearances, the JAPCC maintains the only global refuelling clearance and compatibility matrix, which is a thorough compilation of nationally reported information. A quick scroll through the matrix will highlight that many nations have made great gains in getting clearances, but also that a very large number report clearances with nations that do not report the same clearances in their own National document. Posted on the JAPCC website, the matrix and the source documents on which it is based are accessible to crews and planners even from their smart phones.

Conclusion

The feedback on this first NATO and EU AAR Clearance Request/Approval Training and TTE event is extremely encouraging. The intrinsic tie between the NATO and EU fostered by an overlap of TTE participants and goals highlights the collective benefit of coordinated asset procurement, personnel training, and data sharing. For European organizations already deeply invested in increasing coalition capabilities, sincere commitments from the highest levels of government have validated their work. Furthermore, the JAPCC support provided prior and after the TTE to national headquarters who submit SRDs has been beneficial in encouraging nations to follow a standard. Overwhelmingly, it was requested to hold the AAR Clearance Request/Approval TTE at least annually. To that effect, the next event is tentatively scheduled for January 2018.

'A stronger NATO and a stronger EU are mutually reinforcing. Together they can better provide security in Europe and beyond.'[6]

1. NATO. 'NATO Secretary General Jens Stoltenberg talks to POLITICO'. Online at http://www.nato.int/cps/en/natohq/opinions_132050.htm, accessed 25 Feb. 2017.
2. 'Joint Declaration by the President of the European Council, the President of the European Commission, and the Secretary General of the North Atlantic Treaty Organization'. Warsaw, Poland, 2016. Online at http://www.nato.int/cps/en/natohq/official_texts_133163.htm, accessed 20 Apr. 2017.
3. IHS Jane's. ‚Europe kick-starts tanker procurement project.' 25 Jan. 2014. Online at http://www.janes.com/article/46210/, accessed 20 Apr. 2017.
4. Online at https://www.japcc.org/aar/matrix/.
5. All published SRD can be found at the JAPCC's AAR webpage. Online at https://www.japcc.org/aar.
6. Ibid 2.

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European Security and the Significance of the F-35

By Air Commodore Dr. Frans Osinga

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Introduction

The introduction of F-35 fighters in European air forces marks a momentous transition from 4th generation fighters to the 5th generation. But the F-35 means much more than the mere replacement of one fighter by another one. The real significance of the F35 is strategic and political in nature, and must be assessed from a European security perspective. And that perspective is worrisome.

Addicted to the Air Power Advantage

The west has become addicted to its air power dominance. Since Operation Desert Storm in 1991 the military and political utility of air power has vastly increased. Indeed, a revolution in military affairs took place which was largely based on the rapid evolution in air power capabilities. Stealth fighters and bombers, persistent Intelligence Surveillance Reconnaissance (ISR), the proliferation of precision guided munitions, Suppression of Enemy Air Defence (SEAD) and Electronic Warfare (EW) capability, networking of sensors, shooters and Command and Control (C2) nodes, all combined to make the offence superior to defence in air warfare. The resulting persistent air superiority

The F-35's inherent stealth, EW, SEAD and ISR features address a significant capability gap that threatens to paralyze future European air operations. However, it will be a long time before Europe can boast a substantial number of operational F-35 squadrons. The F-35 will therefore likely become a critical 'high demand-low density' asset needed to ensure NATO can conduct long range precision strike as well as Defensive or Offensive Counter-Air missions in a contested environment.

offered a virtual sanctuary that could be exploited for various purposes, such as ISR, Interdiction, Close Air Support (CAS) and strategic attacks. Air strikes became unprecedentedly accurate. With Precision Guided Munitions (PGMs), one fighter could attack several targets in one mission, including dug-in tanks and artillery and intense air attacks could now obliterate entire armoured columns. The result was a drastic shortening of the time required and the risk involved for ground units to complete the coalition victory, as Operation Iraqi Freedom once again demonstrated. Conventional strategic attack too was rediscovered. Precision munitions, stand-off and stealth capabilities offered new possibilities for strategic attacks against multiple target-categories of a nation state (military units, leadership, and critical infrastructure). Even if targets were in the vicinity of civilian objects, it was now possible to attack these nearly simultaneously in order to rapidly degrade the functioning of the entire 'enemy system' from the first moment of a campaign and cripple the strategic command capabilities before attacking fielded forces. Finally, Desert Storm suggested that military operations need not necessarily entail massive civilian casualties and the measure of 'collateral damage' to civilian infrastructure seemed to be controllable.[1, 2]

In the arena of irregular warfare air power too has made huge strides in effectiveness due to persistent and wide area ISR, highly precise CAS and interdiction with unprecedented short response times and improved air-land integration. In stabilization and Counter-Insurgency (COIN) missions this provides forces protection, allows Special Operation Forces (SOF) teams to cover wider areas than before with lower risk, and can assist so-called proxy-forces. This 'Afghan Model' has proven its worth in Afghanistan (2001–2014), Northern Iraq (2003), Libya (2011) and Mali (2013) and currently in the fight against Daesh.[3] Air power is also one of the few assets available that can target terrorist groups and guerrilla fighters in remote regions, and do so relatively effectively and cheaply without risks associated with the employment of large numbers of ground troops.[4,5]

Enhanced effectiveness and decreased risks translated into greater political utility to the extent that air power has become the 'go-to' military instrument for many international crises. Thus immediately following Operation Desert Storm, offensive air power was employed to enforce No Fly Zones in the context of peace operations in the Balkans and northern Iraq and subsequently also in southern Iraq. During second half of the 1990s western air power was twice pivotal as the key military instrument of Western coercive diplomacy against Serbia (Operation Deliberate Force and Operation Allied Force). In 2003, the US-led coalition used its air dominance so effectively against Iraqi ground forces that the ground offensive proceeded virtually unopposed and with unprecedented speed to Baghdad to topple Saddam Hussein. In 2011, NATO air power was employed in Libya in support of the UN doctrine of Responsibility to Protect, which amounted to a campaign of coercive diplomacy. Indeed, precision age air power suits the western sensibility concerning collateral damage and has become the defining and indeed normative feature of the western way of warfare.

The Air Power Gap: The Paradox

There is a remarkable paradox though. While Europe's security concern from 1990 till 2014 have put an emphasis on expeditionary and power projection capabilities – which are precisely some of the key attributes of air power – Europe disinvested in air power. It has underappreciated the extent to which the new western way of war with its emphasis on risk mitigation, casualty sensitivity, and force protection depends on a continuous umbrella of sophisticated air power assets that provide rapid precision intelligence and if necessary kinetic response capabilities. Europe's often discussed capability gap is largely an air power gap – as became evident during operation Allied Force: US forces catered for 60 % of all sorties, dropped 80 % of all expended ordnance, provided 70 % of all support sorties and 90 % of all SEAD and EW missions, not to mention the fact that without US support NATO would have lacked effective command facilities.[6]

This full munition display of a Boeing B-52 Stratofortess strategic bomber demonstrates overwhelming air power. Since 1990, European NATO nations disinvested a lot in in own air power and therefore became increasingly reliant on such US capability along with important enablers such as EW, SEAD, AAR, ISR, and C2.

Europe was fatally and unacceptably dependent on US 'enablers' and 'precision shooter'. Already in 1997 senior defence analysts warned Europe to 'mind the gap' as Europe was losing its ability to operate alongside US forces.[7]

In response, since 1999 NATO has launched several initiatives, starting with the Defence Capabilities Initiative (DCI), which identified six areas of high priority involving strategic air lift, air-to-air-refuelling (AAR), SEAD, Support Jamming, PGM and Secure Communications.[8] Over the past decade by and large those shortfalls have persisted.[9] Budgetary constraints were one culprit of Europe military deficit,[10] but the heart of the problem is policy re-orientation and force restructuring. Most European armed forces have retained their orientation on static man-power intensive territorial defence. By 2005 Europe still had 1.5 million people in arms, and in excess of 10,000 tanks. But only 10 to 15 % of those troops were actually deployable.[11] NATO thus embarked on a 'Transformation' initiative which stood for accelerated innovation, catching up on the RMA, adopting the Network Centric Warfare concept, improving expeditionary capabilities, and closing the capability gap, in short, adopting the New American Way of War.[12] However, complacency,[13] vested service interests, inter-service rivalry, different perspectives within political and military elites on the necessity to really transform their militaries in light of the absence of real security threats, and other societal priorities – the financial and economic crises – all contributed to the disappointing pace of military innovation in Europe.[14]

Thus, European air forces continued their decline, reducing the number of bases and command facilities and disbanding NATO's once formidable Ground Based Air Defence (GBAD) capabilities. Very few air forces invested in long range stand-off strike, SEAD or EW capabilities. AAR and ISR capabilities grew only very slowly if at all. By 2011 combat capable fighter strength was about 1,200, down from 3,000 two decades earlier, with numbers continuing to fall rapidly annually. This implied that air campaign intensity and sustainability would suffer dramatically, keeping in mind that a small scale air campaign such as Allied Force eventually required about 1,000 combat aircraft. Importantly too, two decades after stealth had demonstrated its huge operational and strategic relevance, no European military had a stealthy 5th Generation aircraft in its inventory.

Addicted to US Support

The over-reliance on US so-called 'enablers' (long range strike, EW, SEAD, ISR, C2) became increasingly problematic for the Alliance. Operation Unified Protector (OUP), the intervention in Libya in 2011, once again demonstrated the severity of the air power gap.[15] In a repeat of Operation Allied Force, OUP was probably impossible without US support despite the fact that it was a very limited operation with only 55–150 daily sorties (it never achieved the 350 daily sortie rate aimed for). Sustainability was becoming a distinct issue, too: a number of European coalition partners had to withdraw their commitment during the operation due to maintenance requirements. Others suffered shortage of precision munitions quite early into the operation, suggesting that stockpiles were dramatically low. Several analysts thus concluded that without US support, European militaries can most likely perform only one moderate-sized operation at a time and will be hard-pressed to meet the rotation requirements of a protracted, small-scale irregular warfare mission.[16] And US support has become in doubt. In June 2011, US Defence Secretary Gates predicted a NATO consigned to 'military irrelevance' in a 'dim if not dismal future unless allies stepped up to the plate […]. US political leaders […] may not consider the return on America's investment in NATO worth the cost.'[17] Moreover, the so-called pivot to Asia implied a significant shift of the US foreign and defence policy from Europe and the Middle East to the East and South-East of Asia.[18] This means that it can no longer be assumed that under any circumstance the US will be willing to make substantial contributions in terms of capabilities and competencies to Europe. Therefore, as one official study noted in 2014, Europe must take into account that it has to be capable of independently securing its interests at the periphery of NATO's geographical Area of Operational Responsibility. 'With the current shortfalls, NATO has a challenge in meeting its Level of Ambition. Given the trends the gap between capability and ambition will only become worse.'[19]

A Revisionist Russia

With the Spring 2014 annexation of the Crimea, the emergence of a revisionist Russia has transformed the air power gap from primarily an operational handicap during expeditionary interventions, as well as a political embarrassment, into a security problem. Russia has become an unpredictable power, according to Francois Heisbourg, and indeed Russia displays increasingly an anti-western political narrative which is fuelled by nationalism, honor, and a historic perception of identity and humiliation by the West. It manifests an enmity towards international law, western institutions and values. It seemingly wants to regain the Cold War era spheres of influence between Russia and Western Europe.[20] Its military doctrine and capabilities seem geared to support this political aim. In waging persistent shadow wars using cyber-operations, the deployment of special forces dressed as civilians and 'little green men', disinformation campaigns and denying involvement, it deliberately tries to remain below the threshold of NATO Article 5. This Hybrid Warfare,[21, 22] however, may not be the real or only problem now facing Western Europe.[23] What the Crimea crisis really demonstrated was the rapid modernization of Russian conventional forces. It demonstrated the ability to conduct intimidating snap exercises – some involving up to 150,000 military personnel – along the borders of Eastern European countries involving large army and air formations. Part and parcel of this new strategy is the threat of nuclear weapons. The combination of these capabilities translates into options to rapidly create facts on the ground forcing NATO and the EU to develop quick responses. Russia could then influence that response by threatening with nuclear escalation.[24] While this does not necessarily mean Russia is prepared for a direct confrontation with NATO, Russian Prime Minister Medvedev did not reassure Western leaders when he stated that there is the risk of a 3rd world war and the emergence of a new cold war.[25]

The 2016 NATO Warsaw Summit communiqué recognizes that Russia's 'aggressive actions, provocative military activities and its demonstrated willingness to attain political goals by the threat and use of force are a source of regional instability and fundamentally challenge the Alliance'.[26] Subsequently, since 2014 a flurry of initiatives was taken to demonstrate resolve and unity, avoid the perception of weakness that Russia could exploit, and to re-assure Baltic, Central European and Scandinavian countries. A renewed emphasis has been placed on deterrence and collective defence.[27] The Very High Readiness Joint Task Force (VJTF) was launched, small headquarters would be established and the NRF was to be expanded. Small military capabilities would be prepositioned in the east, air policing would be intensified and the number of exercises enhanced. In Estonia, Latvia, Lithuania and Poland multinational battalion sized battle groups would be established to 'unambiguously demonstrate, as part of our overall posture, Allies' solidarity, determination, and ability to act by triggering an immediate Allied response to any aggression'.[28]

The A2AD Challenge: Losing the Certainty of Air Superiority

However, Russia's military modernization is particularly geared towards negating NATO's asymmetric advantage in the air power arena, undermining NATO's conventional deterrence capabilities. Russia has invested heavily in Anti-Access and Area-Denial (A2AD) capabilities: EW systems, cyber warfare capabilities, and long range Surface to Surface Missiles (SSM) and Surface to Air Missile (SAM) systems. As a result, today, the West needs to reconsider how to preserve Western supremacy in the commons (sea, air, space and cyberspace) and how to use the commons to project power in a contested environment. As US Air Force (USAF) General Frank Gorenc, then commander of US Air Forces in Europe and Africa stated, 'The advantage that we had from the air, I can honestly say, is shrinking […] Those A2/AD capabilities are fundamentally undermining the essence of the American way of war.[29]

This problem is particularly acute along the borders of Europe and in its heart; Kaliningrad.[30] With its amassed

Russia deployed their most modern, mobile surface-to-air, anti-ship coastal defence, and short-range ballistic missile systems to Kaliningrad. This forms an A2AD bastion posing a threat to large areas of the Baltic region to include NATO and EU territory.

air defence and surface to surface missile capabilities it can deny air operations over large parts of the Baltics and Poland, it can threaten military facilities and transport infrastructure – and thus reinforcement (such as the VJTF) – in eastern Europe and well into Germany and deny the use of sea lines of communications. US capabilities in Europe are not sufficient to tackle this A2AD problem. Russia is increasingly able to create positions of local military advantage in its immediate vicinity, advantages that extend to the ability to seize and hold territory, and then to be able to deploy higher order capabilities, ranging from A2AD systems to nuclear weapons, to block, deter, negate or frighten NATO in its attempts to push these forces back.[31] A RAND study concluded that 'As currently postured, NATO cannot successfully defend the territory of its most exposed members.'[32]

The Meaning of the F-35: Restoring Conventional Deterrence

NATO's array of initiatives since 2014 amount to rediscovering the lost art of conventional and nuclear deterrence, territorial defence and conventional warfare. Air power plays a large role in this. To wit, nine out of 16 NATO capability priority shortfall areas relate to air power. In no small measure the conventional deterrence problem equates with ensuring deterrence credibility by addressing the persistent capability gap in which Air C2, Airborne Electronic Attack (AEA), AAR, long range precision strike, SEAD, ISR, air superiority, and Theatre Ballistic Missile Defence (TBMD) feature prominently. Without improving air defence and strike capabilities, NATO will be hard pressed to effectuate conventional deterrence. The certainty of the air sanctuary has disappeared. Against Russia's SAM systems, NATO air defence and offensive counter air operations will once again become a slugging match. Russia's SSMs form a direct threat to NATO's concentrated few scarce Air C2 facilities and air bases. Joint campaign plans therefore once again need to consider careful allocation of assets and phasing; warfare like Desert Storm and Iraqi Freedom is likely infeasible. Information dominance will not happen as ISR missions may well be impossible. Finding and killing SAM systems and the related C2 facilities may subsequently take a very long time. During this phase, Interdiction and CAS missions with current PGMs such as the Joint Direct Attack Munitions (JDAM) will produce high attrition rates until long range stand-off munitions can 'outrange' the Russian SAMS systems. Campaign intensity, persistence and sustainability will become a pressing concern as will ammunition stockpiles, the scarcity of military airfields with hardened facilities, the lack of GBAD, and the lack of redundancy in Air C2 facilities.[33]

While the introduction of the F-35 in Europe certainly does not solve all issues, it ensures interoperability with the US military, it limits the operational dependency on US support in air campaigns and its inherent stealth, EW, SEAD and ISR features address a significant capability gap that threatens to paralyze future European air operations. It will become a critical asset in Europe's air defence and strike capabilities as non-stealth platforms have a very limited chance of survival in the face of Russia's A2AD threat. The F-35 will probably also be called upon as SEAD and sweep escort for 4th Generation fighters which will continue to form the backbone of many European operations. But quantity is a quality. It will be a long time before Europe can boast a substantial number of operational F-35 squadrons and even when these are all-in theater, the number of F-35s will probably never exceed 500. The F-35 will thus become a critical 'high demand-low density' asset ensuring NATO can conduct long range precision strike missions as well as Defensive or Offensive Counter-Air missions in a contested environment. All this implies that the F-35 will become a crucial foundation for NATO's conventional deterrence and war fighting capability in the new A2AD era. And with the proliferation of modern SAM systems (as well as 5th Generation Chinese and Russian fighter aircraft) to many other states, the introduction of the F-35 is a first necessary step to ensure European air forces remain capable to conduct interventions effectively and with modest risk levels that Europe's politicians and publics have become accustomed to. That is the real significance of the introduction of the F-35. ●

1. This brief overview of air power developments draws from: Frans Osinga, 'Air warfare in the postmodern era'. In Julian Lindley-French and Yves Boyer (eds.), The Oxford Handbook of War, Oxford University Press, 2010.
2. For descriptions of the new western way of war see for instance: (1) Martin Shaw. 'The New Western Way of War'. Polity Press. London, 2005. (2) Christopher Coker. 'Humane Warfare; the New Ethics of Postmodern War'. Abingdon. Routledge, 2002.
3. For an up to date discussion of air power in COIN see: Joel Hayward (ed.). 'Air Power, Insurgency and the "War on Terror"'. Royal Air Force Centre for Air Power Studies. Cranwell, 2009.
4. Benjamin Lambeth. 'Air Power Against Terror'. RAND. Santa Monica, 2005.
5. For a welcome study of the air operations of Iraqi Freedom, see: Benjamin Lambeth, 'The Unseen War, Allied Air Power and the Takedown of Saddam Hussein'. Naval Institute Press, 2013. Annapolis, MD.
6. For a full analysis, see for instance John Peters et al. 'European Contributions to Operation Allied Force; Implications for Transatlantic Cooperation'. RAND. Santa Monica, 2001.
7. David Gompert, Richard Kugler and Martin Libicki. 'Mind the Gap, Promoting a Transatlantic Revolution in Military Affairs., Institute for National Strategic Studies, National Defence University Press. Washington, D.C.
8. This discussion draws from: Frans Osinga. 'The Rise of Transformation'. In: Theo Farrell, Terry Terrif and Frans Osinga. 'A Transformation Gap, American Innovations and European Military Change'. Stanford University Press. Stanford, 2010.
9. For a very detailed study of European air power developments and the problem of the air power gap, see: Christian Anrig. 'The Quest for Relevant Air Power'. Air University Press. Maxwell AFB, Alabama, 2011.
10. Kees Homan, Bert Kreemers, Frans Osinga. 'De Militaire Staat van de Europese Unie'. Clingendael Research Paper. The Hague, May 2001.
11. For a detailed account, see: Bastian Giegerich and William Wallace. 'Not Such a Soft Power: the External Deployment of European Forces'. In Survival, vol. 46, no. 2. Summer 2004, p. 163–184.
12. For this argument, see for instance: (1) David Gompert and Uwe Nehrlich. 'Shoulder to Shoulder, The Road to US-European Military Cooperation'. RAND. Santa Monica, 2002. (2) Hans Binnendijk and Richard Kugler, 'Transforming European Forces'. In Survival, vol. 44, no. 3. Autumn 2002.
13. Hans Binnendijk. 'The Impact of Global Trends on Air and Space Power in NATO'. In: Air and Space Power in NATO, Future Vector Part I. Joint Air Power Competence Centre, Kalkar. Jul. 2014, p. 39.
14. Stephen Larrabee, Stuart E. Johnson, et al. 'NATO and the Challenges of Austerity'. RAND. Santa Monica, 2012, p. IX.
15. For an excellent comprehensive study of OUP and its implications for the Alliance, see: Karl Mueller (ed), 'Precision and Purpose, Airpower in the Libyan Civil war'. RAND, Santa Monica, 2015.
16. Ibid 14.
17. Ian Traynor, 'US Defense Chief Blasts Europe over NATO'. The Guardian, 11 Jun., 2010.
18. U.S. Department of Defense. 'Sustaining U.S. Global Leadership: Priorities for 21st Century Defense'. Jan. 2012.
19. Joint Air Power Competence Centre. 'Diminishing Air Power Capabilities'. In Present Paradox, Future Challenge. Kalkar, Mar. 2014, p. 77.
20. For such an assessment of the challenge that Russia poses to Western Europe, see for instance: (1) Matthew Kroenig, 'Facing Reality: Getting NATO Ready for a New Cold War'. In, Survival, Volume 57-1, 2015. P. 49–70. (2) François Heisbourg. 'Preserving Post-Cold War Europe'. In Survival, Volume 57-1, 2015, p. 31–48.

While the introduction of the F-35 in Europe certainly does not solve all issues, it ensures interoperability with the US military and it limits the operational dependency on US support in air campaigns.

21. For a discussion of Russia's hybrid warfare concept see for instance: Alexander Lanoszka. 'Russian Hybrid Warfare and Extended Deterrence in Eastern Europe'. In: International Affairs Volume 92-1, 2016, p. 175–195.
22. For a lengthy treatment of Russian Hybrid Warfare from a NATO perspective, see: Guillaume Lasconjerias and Jeffrey Larsen (eds). 'NATO's response to Hybrid Threats'., Forum Paper 24, NATO Defence College. Rome, 2015.
23. (1) Mark Galeotti. 'Hybrid, ambiguous, and non-linear? How new is Russia's 'new way of war'?' In Small Wars & Insurgencies, Volume 27-2, 2016, p. 82–301. (2) Samuel Charap. 'The Ghost of Hybrid War'. In Survival, Volume 57-6, 2015, p. 51–58.
24. See Elbridge Colby & Jonathan Solomon. 'Facing Russia: Conventional Defence and Deterrence in Europe'. In Survival, Volume 57-6, 2015. P. 21–50. (2) Johan Norberg. 'Training to Fight: Russia's Major Military Exercises 2011–2014'. Swedish Defense Research Agency (FOI) Report. 5 Dec., 2015. Online at: https://www.foi.se/reportsummary?reportNo=FOI-R--4128--SE (accessed Jan. 2016), p. 62.
25. Sam Jones. 'Dmitry Medvedev warns of "new cold war". Financial Times, 13 Feb 2016, online at http://www.ft.com/cms/s/0/a14e8900-d259-11e5-829b-8564e7528e54.html #axzz4liVoaRgz.
26. 'Warsaw Summit Communiqué'. Issued by the Heads of State and Government participating in the meeting of the North Atlantic Council. Warsaw 8–9 Jul. 2016. Online at http://www.nato.int/cps/en/natohq/official_texts_133169.htm.
27. Ibid.
28. Ibid. See the communiqués of Wales and Warsaw for the full array of initiatives and plans.
29. Franz-Stefan Gady. 'US Air Force: Russia Has Closed Air Power Gap With NATO'. In The Diplomat, 16 Sep. 2015. Online at http://thediplomat.com/2015/09/us-air-force-russia-has-closed-air-power-gap-with-nato/.
30. Stephan Frühling and Guillaume Lasconjarias 'NATO, A2/AD and the Kaliningrad Challenge'. In Survival, Volume 58-2, 2016, p. 95–116.
31. Dave Majumdar. 'Can America Crush Russia's A2/AD "Bubbles"?'. In The National Interest, 29 Jun. 2016. Online at http://nationalinterest.org.
32. David A. Shlapak and Michael Johnson. 'Reinforcing Deterrence on NATO's Eastern Flank: Wargaming the Defense of the Baltics'. RAND Santa Monica, 2016, p. 1
33. (1) Jay Ballard. 'What is Past is Prologue – Why the Golden Age of Rapid Air Superiority is at an End'. In Journal of the JAPCC, Edition 22, Spring/Summer 2016, p. 56–64. – (2) Timothy Walton. 'Securing the Third Offset'. In Joint Forces Quarterly 82, 3rd Quarter 2016: p. 6–15.

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Fifth Generation Air Combat

Maintaining the Joint Force Advantage

By Major General Jeff Harrigian, USA AF
By Colonel Max Marosko, USA AF

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Fifth Generation Aircraft, Defined

For the purposes of this paper, we must define what a 'fifth generation' aircraft means in the context of modern military operations. A fifth generation aircraft is capable of operating effectively in highly contested combat environments, defined by the presence of the most capable current air and ground threats, and those reasonably expected to be operational in the foreseeable future. Currently fielded fifth generation aircraft include the Air Force's F-22A Raptor and the US Marine Corps F-35B Lightning II, with the USAF F-35A targeted to achieve initial operational capability later this year.

There are many characteristics of fifth generation aircraft that separate them from older aircraft. These include, primarily, multi-spectral low observable (LO) design features (such as radar, infrared sensors, and visual situational awareness tools), along with self-protection and radar jamming capabilities that delay or deny enemy systems the ability to detect, track, and engage the aircraft. These aircraft also feature integrated avionics, which autonomously fuse and prioritize the aircraft's multi-spectral sensors and off board data, providing an accurate real-time operations picture for the pilot, and the ability to download data for post-mission analysis. This is a present-day example of 'man-machine teaming'. Advanced on-board diagnostics help vital monitoring of the aircraft's health, accurately reporting faults as they occur, increasing overall system performance and reliability.

Resilient communications, navigation, and identification tools and techniques are also crucial aspects of fifth generation aircraft, designed to counter enemy attempts to jam, deny, or confuse these vital capabilities. Fifth generation aircraft are also empowered by robust networks, linking individual aircraft to create a common, accurate, and highly integrated picture of the battle space for friendly forces. The aircraft and its subsystem designs are also closely integrated, far more intricately than older aircraft. This helps to maximize lethality and survivability while enabling decision-making superiority by reducing the number of actions required by the pilot. The effect of these tools in total turns operators of these advanced aircraft into mission commanders, rather than having them focus on managing and operating subsystems (like in older third and fourth generation 'legacy' aircraft). Despite their capability, at present fifth generation aircraft comprise a fraction of the current combat air forces. The average age of a current USAF airframe is 27 years, and rising.[1] Modernizing fighter and bomber forces with sufficient numbers of fifth generation aircraft is critical for continued combat relevance, especially in light of three important trends:

- Modern Integrated Air Defence Systems (IADS) have created regions where fourth generation aircraft cannot effectively penetrate and hope to survive.[2]
- Threat aircraft, air-to-air missiles (AAMs), electronic attack (EA), and electronic protection systems have advanced beyond the capabilities of US fourth generation fighters.[3]
- Fifth generation aircraft provide a wider variety of wartime options in many scenarios, preserve US technological advantage over near-peer threats, and serve as force multipliers by increasing the situational awareness and combat effectiveness of legacy aircraft.

© US Air Force

Fifth generation aircraft such as the F-22 Raptor (depicted here in front), or the F-35, have many unprecedented, modern features that separate them from older aircraft such as the F-16 Falcon, A-10 Thunderbolt II and the legacy F-4 Phantom II (left to right).

Understanding Fifth Generation Operations

An effective capability, such as fifth generation aircraft, is only a tool and must be properly utilized with effective preparation to perform at its best and empower joint operations fully. To achieve success with any fifth generation aircraft requires all personnel associated with the generation and employment of these capabilities, to include aircrew, maintenance, and support personnel, to optimize their roles in ensuring effective combat operations.

Airmen must have an intuitive understanding of their aircraft and how it performs in relationship to the threats it might encounter.[4] They must train for the most demanding scenarios against the latest IADS and enemy aircraft, and US military services, allies, and partner nations must also develop a strategy with fiscally realistic and executable plans to adequately train against advanced adversary advanced capabilities (including air-to-air, surface to air, space, and cyber threats). These plans and preparations must include an appropriate mix of live, virtual, and constructive (LVC) training scenarios and exercises. This is of added importance in the context of fifth generation aircraft, as flight simulator training is even more important than with older aircraft. To a greater extent than training with legacy aircraft, fifth generation simulators must provide realistic training through timely concurrency with the aircraft, sufficient fidelity for realism, and appropriate connectivity to other assets for realistic exercising. In addition to operators, maintenance personnel require more training to adequately keep up fifth generation aircraft and their vital low radar signatures.

To improve survivability against adversary IADS, the signatures of fifth generation aircraft must be actively managed, much like airframe inspection and engine maintenance schedules.[5] Commanders must ensure that training resources are adequately provided for these assets to capitalize on the unique capabilities they bring to the operational environment. All personnel must be trained to understand the importance of specialized security requirements for fifth generation aircraft. From ensuring physical security and cyber standards to balancing protection of classified

Inside an F-35 mission simulator: Fifth generation simulators must provide realistic training through timely concurrency with the aircraft, sufficient fidelity for realism, and appropriate connectivity to other assets for realistic exercising.

capabilities with realistic training, personnel must appreciate and carry out security guidelines for daily operations effectively, as well as those for allied, coalition, and partner training exercises and combat operations. Lastly, commanders and support personnel must understand the fifth generation aircraft global sustainment system, for both home station and during deployed operations. Commanders should consider and actively track changing threat conditions, and how these can impact the ability to sustain their fifth generation operations.

Fifth Generation Airpower and Data

Fifth generation aircraft bring incredible capability into combat. But they are also some of the most data-dependent machines in the US inventory, and require significant amounts of information in order to operate at their best.

Fifth generation aircrew and aircraft rely on mission data files to enable on-board systems to accurately identify friendly, neutral, and adversary systems. This data allows fifth generation pilots to enhance their stealth, or low observable (LO) signature management, enabling the aircraft to survive and maintain situational awareness of events in combat even when operating in close proximity to advanced threats. The US Air Force, sister services, allies, and the intelligence community have an essential role in populating and updating these files. Not only is this mission data necessary for internal operation of these aircraft, this data also contains the capability for fifth generation systems to communicate their fused sensor products off board to other aircraft, providing an integrated common operating picture of a conflict or contingency. In the future, near-real time exploitation of fifth generation aircraft's unique information collection capabilities will become increasingly mandatory to operate in more sophisticated threat environments.

To achieve true combat systems integration, this fused sensor information must be linked up with USAF's much larger legacy aircraft forces and select command and control nodes via data links and cloud-based communication architectures. By linking this information to the entire force, an actionable common operating and targeting picture can be created for commanders and decision makers. As sensors, communication protocols, and data links improve, all friendly forces should be able to share the multi-domain situational awareness fifth generation aircraft can generate, in cooperation with other assets. To perform this effectively, though, requires a detailed systems understanding of data link architectures, and protocols to ensure communication compatibility across the enterprise.

Deploying and Sustaining Fifth Generation Airpower

Squadrons of fifth generation aircraft deploy today extensively, much like fourth generation units that preceded them (aircraft such as F-16s, F-15s, and others). But to realize the potential of fifth generation aircraft in modern joint operations, fifth generation communities in the USAF must make several improvements.

First, units must improve deployment reaction time and speed, as windows of opportunity to penetrate IADS or to destroy high value targets may be fleeting. Second, fifth generation aircraft units must work diligently to minimize the required amount of forward-deployed equipment and personnel, and fully understand the logistics, sustainment, and communications limitations at a deployed location. Third, the Air Force must work to increase flexible basing options available for fifth generation aircraft (such as increasing the number of airfields the Air Force can deploy to), and build a fuller understanding of the impact these options will have on operations, maintenance, and command and control in dispersed locations.

This includes not only conducting combat operations from bases owned by our international partners, but also operating at relatively austere locations. Deploying and operating from limited support locations does come with some challenges. The US and its allies must ensure support (logistics and connectivity) can be delivered to forward airfields where commercial carriers may not operate. Finally, fifth generation aircraft sustainment and support systems must be hardened with sufficient redundancy to ensure resilience under attack. This hardening must be multi-domain, and the sustainment and support systems must be able to survive and operate in the face of both kinetic and cyber attack.

Successful Employment and Sustainment Across the Spectrum

Combat employment of air assets may occur across a wide spectrum of potential conflicts, from permissive environments, where legacy and fifth generation aircraft can operate together with ease, to highly contested environments, where only fifth generation aircraft can operate effectively. In permissive or moderately

Deploying and operating from limited support locations does come with some challenges. Fifth generation aircraft units must fully understand the logistics, sustainment, and communications limitations at a deployed location.

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F-35 and F-16 pilots begin integration training at Luke AFB in Octobre 2016. Fifth generation aircraft can destroy or degrade enemy defences to create an environment where legacy aircraft can operate with relative freedom of action. This often requires fifth generation aircraft (such as the F-35) to operate on the leading edge of the force package, allowing legacy aircraft (such as the F-16) to ingress and destroy priority targets.

contested environments, the force packaging of airpower can combine both legacy and fifth generation aircraft to maximize survivability, and the lethality of the force. Since legacy aircraft sensors alone may be insufficient to detect threats, or may be overwhelmed by the quantity of threats, fifth generation aircraft may provide the most utility by sharing their fused operations picture via a well-constructed data link feeding this information into the communications architecture, which disperses this picture to as many legacy aircraft as possible.

Likewise, legacy aircraft increase a force's ordnance capacity due to the limited internal carriage configurations of fifth generation aircraft. Modern fifth generation aircraft can offer targeting solutions for fourth generation assets via established data links, while themselves targeting threats only by exception. This gives commanders an incredible amount of operational flexibility. In highly contested environments, an air component commander might use only fifth generation aircraft to bypass an IADS and neutralize the objective. Alternatively, fifth generation aircraft can destroy or degrade enemy defences to create a temporary or localized permissive (or semi-permissive) environment where legacy aircraft can operate with relative freedom of action. This often requires fifth generation aircraft to operate on the leading edge of the force package, allowing legacy aircraft to ingress and destroy priority targets.

Once combat begins, however, adversaries may adjust tactics, as well as the operating parameters of their systems. Thus, leaders will need to ensure that appropriate intelligence, surveillance, and reconnaissance (ISR) assets report this information quickly to the mission data enterprise supporting fifth generation aircraft and other elements of joint force operations. There must be a robust processing exploitation dissemination (PED)-like process for analysing the data fifth generation aircraft collect. Commanders need to proactively ensure operations data is linked properly with the intelligence enterprise. This linkage will allow for the proper analysis of information, and more importantly, the proper application of learned information. This kind of seamless information sharing must be achieved to enable rapid reprogramming and re-release of mission data files for optimum employment of all allied assets.

In order to make this employment concept a reality, collaboration is critical. USAF units must be able to share lessons with other US military services and, as required, select allied and coalition partners. Sharing with international partners while balancing security concerns will be paramount to successful future fifth generation aircraft employment. Joint and combined training, exercises, and even 'cross talks' at forums like tactics conferences and training review boards will also be critical learning and development opportunities. In addition, it is necessary to ensure fifth generation pilots, as well as maintenance and logistics personnel, fill key billets on major command, headquarters, and joint staff positions to inform senior leaders, and enable appropriate enterprise-wide resource planning and decision making.

The Air Force must understand how the logistics enterprise can support the unique capabilities of fifth generation aircraft both in garrison and during deployed operations. While deployed, leaders and commanders must understand how to leverage in-theatre fifth generation assets, along with sister US military service or partner nation logistics networks.

Maintenance of fifth generation aircraft also requires careful planning to keep the force ready for combat operations. While fifth generation aircraft require the same maintenance considerations as legacy aircraft, such as maintaining flight systems and engines, there are additional requirements to maintain their low observable (LO) characteristics. This adds another level of complexity USAF leadership must proactively manage. The Air Force must understand how the logistics enterprise can support the unique capabilities of fifth generation aircraft both in garrison and during deployed operations. While deployed, leaders and commanders must understand how to leverage in-theatre fifth generation assets, along with sister US military service or partner nation logistics networks. When the answers to these sustainment challenges are discovered, they should be analysed rapidly with respect to the changing phases of a given campaign, training exercise, or other engagement involving fifth generation aircraft.

Conclusion: Employing Our Advantage for Joint and Combined Force Operations

Employing these aircraft in future combat requires careful attention across several phases and aspects of employment beyond the aircraft themselves. These aspects include advanced planning, preparation, ensuring effective use and dissemination of mission data, how deployment of fifth generation aircraft is conducted, actual combat employment design, and supporting operations with appropriate logistics and sustainment practices.

While fifth generation aircraft do not provide decision makers with a single-point solution, their demonstrated ability as valued contributors to strategic deterrence, capacity as advanced airborne echelons, and operational utility as enduring force multipliers make them indispensable to future joint force operations.

In addition to the elements of fifth generation airpower described in this paper, future concepts of employment should aim to focus on several integration priorities. These areas include refining connectivity between legacy and fifth generation aircraft, improving connections between fifth generation airborne platforms, improving integration with space and cyber capabilities, and integrating fifth generation platforms with other components of joint and combined force operations. Integration advances in these areas will aid progress towards the goal of creating a cloud-based architecture where every element of air, space, and cyber power contribute to conducting disaggregated, distributed operations over a wide area. The complementary employment of capabilities from all domains will enhance the effectiveness of future combat operations, and help compensate for vulnerabilities.

The need to explore these concepts will only increase. In the coming decade, fifth generation aircraft will grow and mature in sufficient numbers to give the US and our allies a definitive strategic advantage to counter the advancement of modern weapon systems used by potential adversaries. These potential adversary weapon systems, from aircraft to cruise missiles to advanced SAMs and cyber capabilities, are currently contributing factors to the destabilization of contested regions around the world. Fifth generation aircraft are critical to returning the military balance to our favor. Along with thoughtful integration and investment in select legacy aircraft, the maturation of fifth generation aircraft capabilities in sufficient numbers will better enable joint force operations that will provide the US and its allies a wider range of options to secure our interests in a scenario which could emerge in the coming years. ●

1. Secretary James and Gen Welsh, 'Fiscal Year 2015 Air Force Posture Statement', p. 6.
2. Surface to Air Missile (SAM) capability available for export from countries like Russia and China has steadily increased in recent years. Relatively inexpensive SAMs increasingly provide an improved barrier for nations seeking defences against air attack, especially against older aircraft. Maximum ranges and targeting capability for these SAMs have immensely improved, and many are often mobile, presenting a challenging targeting set for fourth generation systems. While these SAMs remain a formidable threat, fifth generation systems have a greater capacity to overcome and operate in environments defended by these weapons.
3. The US DOD has not heavily invested, compared to our adversaries, in electronic attack (EA) capabilities for our fighters. Over the years, we have continued to rely upon the X band in the Radio Frequency (RF) spectrum for our targeting and engagement capability and therefore, continue to play 'catch up' in countering their advancements in EA capabilities. This history, combined with advancements in air-to-air missiles and adversary employment ranges, increases the risk to our legacy assets. The characteristics of fifth generation aircraft mitigate that risk.
4. Fifth generation aircrew must understand their aircraft's signature and its expected detectability against threats. While pilots can expect their aircraft will be within the expected signature specification at the start of a mission, degradation can occur. All aircrew must know when they should and should not expect to be detected, to enable necessary adjustments for a given mission.
5. Maintaining fifth generation aircraft signatures is similar to managing the hours until the next inspection or engine maintenance schedules of legacy aircraft. The signature of an entire squadron of fifth generation aircraft must be tracked and managed very closely. If not managed, the man-hour bill required to bring a squadron of aircraft back to specification can quickly become unmanageable, impacting aircraft availability and training.

Lieutenant General Jeffrey L. Harrigian

is Commander, US Air Forces Central Command, Southwest Asia. As the Air Component Commander for US Central Command, the General is responsible for developing contingency plans and conducting air operations in a 20-nation area of responsibility covering Central and Southwest Asia. He has served in a variety of flying and staff assignments, including Deputy Director for Strategy, Plans and Assessments, US Forces-Iraq, in support of Operation Iraqi Freedom and as Chief of the Joint Exercise Division at NATO's Joint Warfare Center, Stavanger, Norway. Prior to his current assignment, General Harrigian served as Director, F-35 Integration Office at Headquarters Air Force in the Pentagon, Washington, D.C. The General is an Air Force Weapons School graduate and a command pilot with more than 4,100 flight hours in the F-22, F-15C, A/OA-37 and MQ-11.

Colonel Max M. Marosko III

is a United States Air Force F-22 Raptor pilot, currently serving as the deputy director for air and cyberspace operations at Headquarters Pacific Air Forces, JB Pearl Harbor-Hickam, Hawaii. Marosko served multiple combat tours in the F-15C prior to transitioning to the F-22. In addition to serving as an Air Force Weapons School instructor in both the F-15C and the F-22, Marosko has commanded an F-22 squadron, and previously served as the 325th Operations Group commander at Tyndall AFB, Fla. prior to his current assignment. At the 325th OG, he oversaw the operations of both an operational F-22 squadron and the Air Force's only F-22 training squadron. He also served in the initial training cadre for USAF's F-22 Formal Training Unit (FTU), and is a graduate of the National War College at Fort McNair, Washington, DC.

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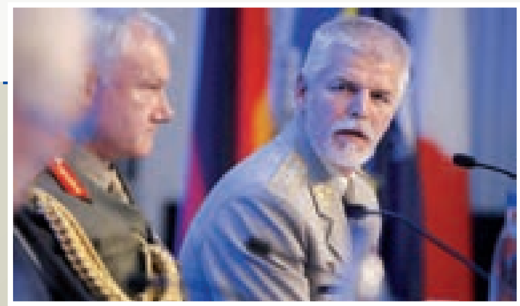

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Fifth generation aircraft type F-22 and F-35 for the first time train together. Both the F-22 and F-35 have proprietary, directional datalink systems, which permit a high level of secure data transfer with each other, but have limited to no connectivity to other platforms.

JAPCC Perspective on the Fifth Generation Aircraft Discussion

Air Warfare Communication in a Networked Environment

By Captain William A. Perkins, USA N, JAPCC

By Lieutenant Colonel Carlos Presa-Diaz, Ph.D., ESP AF, JAPCC

By Colonel Joseph Speed, USA AF, JAPCC

This article will provide JAPCC's perspective on 5th Generation Aircraft and highlight some integration challenges which the Alliance must address, with specific regard to themes discussed in the two articles preceding this one (Osinga, Harrigian). Although there is currently no NATO-wide accepted definition of 5th Generation aircraft, it is commonly accepted that unlike previous generations of fighters, which were defined by aerodynamic performance capabilities, 5th Generation fighters are categorized based on information development and data fusion capabilities meshed with stealth technology.[1] Many articles, studies, and concepts of operational employment recognize information fusion and sharing derived from 5th Generation technology is a true force multiplier across the battlespace. It is this 'generational leap forward' that underpins future air warfare and is the focal point of a soon-to-be published JAPCC study. However, some challenges remain for integration with other Alliance air platforms. These challenges must be addressed holistically to ensure NATO is able to operate 5th Gen and legacy systems in concert and is capable of deterring, and if necessary defeating potential adversaries, as 5th Gen systems will not be ubiquitous enough to carry the fight alone, at least for the foreseeable future.

Integrating 5th Generation Aircraft into the Joint Battlespace

Both the F-22 and F-35 have proprietary, directional datalink systems, which permit a high level of secure data transfer with each other, but have limited to no connectivity to other platforms. Many engineering solutions, including external datalink pods and other networking solutions, are under development to address this issue. However, the desire to incorporate these capabilities into the joint battlespace introduces a debate about how best to integrate these new systems with legacy platforms within conventional Command and Control (C2) structures. Integration may be achieved either through technological means (creating a datalink which passes information across generations) or through training. The latter would necessitate an improvement in NATO's high-end, multi-component live training, which would have to occur against a quality adversary with a realistic rule set governing adjudication and the conduct of the exercise. This is critical not only for assessing NATO's current preparedness for operations in this demanding and contested environment, but also for identifying shortfalls and focal points for improvement.

Further Challenges for the Alliance to Consider

Acceptance. Some nations operating legacy aircraft may struggle to accept being tactically dependent on 5th generation assets, flown by another nation, for targeting and engagement. This means that using 5th generation aircraft to detect, inform, and direct legacy aircraft serving as 'missile trucks' would likely not be accepted in the same way by every nation and in each tactical scenario.

Restrictions and Caveats. Shared locations/briefings/missions/training airspace and dispersal plans with other Coalition assets will initially be challenging due to national restrictions, sensors and communications compatibility, need to know, software upgrade costs and other factors. A 'plug and play' multinational force is desirable, but is likely not achievable in the near term due to national caveats regarding information sharing.

Cross Servicing. The viability of cross servicing among multinational F-35 users is questionable, and although NATO is currently re-invigorating its logistics and cross-servicing arrangement, those procedures are far from being codified. Furthermore, different users will have different arrangements with Industry. Maintenance contracts will differ from nation to nation, making cross-servicing even more challenging.

Airspace Saturation. Airspace saturation with manned aircraft, or the usage of Remotely Piloted Aircraft (RPA) or Miniature Air Launched Decoys (MALDs) by the adversary, among other tactics, could potentially negate a successful air-to-air reliance on the F-35 alone. This reinforces the concept that 5th generation and legacy aircraft must operate together in the future battlespace, as the war will not be won with only 5th generation aircraft.

Support versus Replace. Fifth generation assets are not the single solution for Anti-Access Area Denial (A2AD) layered defence systems. Rather they may become part of a more holistic and integrated solution when paired together and connected with other weapons and sensors, such as direct energy weapons or unmanned aerial vehicle swarms such as the Gremlins – a concept developed under the US Defense Advanced Research Projects Agency (DARPA).[2] If leveraged correctly, this could be a true benefit of 5th generation aircraft. However, the Alliance should also be cautioned to remember that mass has a quality in warfare, and that advent of 5th Generation technology in many nations inventory will replace not add to the existing 4th Generation systems, in many cases in smaller numbers than exist today.

Different Employment Perspectives. Some opine that operators of 5th generation technology will elevate beyond a pure 'sub-element operator' role (and even beyond the classic mission commander role) into a partial C2 node, which enhances resiliency and improves task completion and information distribution functions. This perspective is not shared by all NATO nations participating in the F-35 program, but it is perhaps too early to make an accurate prediction as to what level this vision will be realized.

The crux of the integration challenge issue remains ensuring information fusion among and across the disparate platforms which currently are – and will be in the near future – in use across the spectrum of NATO's Joint Air Power. Fifth generation fighters won't win the war themselves, rather they will improve the capability of each legacy platform, once the technical challenges of interoperability are solved. As Lieutenant Colonel George Watkins, Commander of the USAF 34th Fighter Squadron concluded after Exercise Red Flag 2017-1, '[where it had previously been required to employ numerous 4th generation aircraft just to find and engage a single threat, …] *now we are seeing three or four […] threats at a time. Just between the [5th generation aircraft], we are able to geolocate them, precision-target them, and then we are able to bring the 4th generation assets in behind us after those threats are neutralized. It's a whole different world out there for us now. When you pair the [5th generation aircraft] together with the 4th generation strikers behind us, we're really able to dominate the airspace.'*[3]

JAPCC Project: Air Warfare Communication in a Networked Environment

To address the crux information fusion issue noted earlier, the JAPCC will soon publish a study *'Air Warfare Communication in a Networked Environment'* which explores not only the interoperability challenges between current 5th generation and legacy aircraft, but also examines, from an interdisciplinary perspective, the fundamental relationship between air platforms viewed as a function of the communications capability. These concepts are then extrapolated onto the future operational environment where air platforms operate with hyper-connectivity in a robust, networked environment which enables machine-to-machine coordination. As communications capability increases, machines are able to self-synchronize the spatial orientation of weapons and sensors throughout the battlespace, allowing for more efficient use of those systems at a much higher decision speed than today's airspace management and decision making structure permits.

Hyper-connected platforms will likely become mutually supporting from a bottom-up perspective. Establishing a hierarchy within their functions and roles may solve these mutual support needs. This can be achieved by the depiction, in real time, of who has the best available position, sensor or weapon.

Contextually, the force, comprised of individual platforms, will then behave as a singular entity operating at faster speeds, enabled by communication. One platform's

Fifth generation fighters won't win the war themselves, rather they will improve the capability of each legacy platform, once the technical challenges of interoperability are solved. The crux of the integration challenge issue remains ensuring information fusion among and across the disparate platforms.

sensor may coordinate for a second platform's weapons system to engage while using a third platform as a jammer, or as a SEAD asset with the proper platform´s configuration. Altogether, they would share a software-driven spatial motion policy and behave as a single organism.

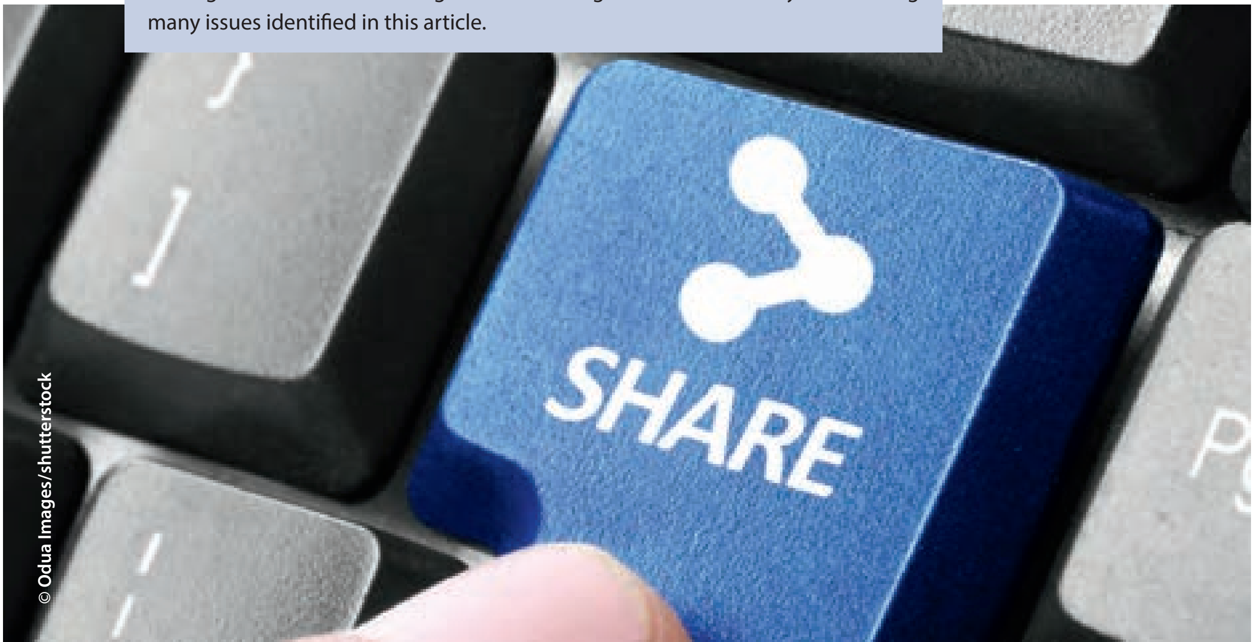
Unlimited connectivity is no longer a concept for the future; however, combined decision-making and data sharing are not evolving at the same speed as technology. Furthermore, tactical scenarios that require the integration of 4th, 5th, and future generation assets will have to be analysed under a new, more general C2 concept to avoid mixing tomorrow's capabilities with yesterday's C2 structures. The impact of 5th and beyond generation air platforms will be realized through the development of spatial awareness using advanced sensors and sharing that information across the network to enable more efficient spatial distribution of resources, which may reduce the commander's decision making timeline accordingly.

The authors created the term Dynamic Airspace Synchronization (DyAS) to describe how machines will communicate at hyperspeeds to self-synchronize for efficient airspace utilization, including weapons and sensor employment. The resultant battlespace will allow multiple platforms to appear to operate as a singular organism. The study concludes that the future battlespace may be choreographed and orchestrated by machines (a machine-managed order of battle) while retaining the ethical necessity of a human decision maker for certain kinetic functions.

Conclusion

The JAPCC believes that solving the Information Sharing element of Integration will be the key to unlocking many of the other issues identified in this article. Some headway with technical solutions has been made already (Talon HATE pod[4] for example) but these solutions reside mostly within national channels and will require further coordination to achieve the same interoperability across the Alliance. Most of the additional challenges identified in this article can, and will, be solved through evolving doctrine and training, or addressed through modifications to international agreements (e.g. aircraft cross-servicing) as nations gain initial operational capability and begin working together. These challenges are not appreciably different from those faced by NATO in the past when a new technology arrived for use (Link 16 for example). Information fusion and C2 integration may be a tougher nut to crack, but is essential for the future of effective Alliance air power. 5th Generation aircraft in the joint fight can improve battlespace awareness, which when properly networked and shared across the force with legacy aircraft, will likely result in a tangible increase in overall combat effectiveness. Integrating manned and unmanned systems while leveraging the capabilities of machine speed communications, both within the cockpit and among platforms throughout the joint battlespace, are requisite to maximize the capability of the future air force. This requires the development of a more robust datalink, or network of links, to permit an even higher level of information

Solving the Information Sharing element of Integration will be the key to unlocking many issues identified in this article.



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exchange across the networked force, which could then leverage machine-to-machine communication, integrate some levels of automation to formation and sensor employment, and result in a more streamlined and effective Command and Control structure for the Alliance. ●

1. Laird, Robbin. 'A 21st Century Concept of Air and Military Operations'. Defense Horizons Edition 66, Mar. 2009.
2. Freedberg, Sydney. 'How to Land A Drone On A Manned Airplane: DARPA's "Gremlins"'. Breaking Defense, Sep. 2016. Available at: http://breakingdefense.com/2016/09/how-to-land-a-drone-on-a-manned-airplane-darpas-gremlins/ [23.01.17].
3. Rogoway, Tyler. 'Lets Talk about those F-35 Kill Reports from Red Flag'. The Warzone. 8 Feb. 2016 Available at: http://www.thedrive.com/the-war-zone/7488/lets-talk-about-those-f-35-kill-ratio-reports-from-red-flag
4. Hunter, Jamie. 'USAF puts Talon HATE to the test'. IHS Jane's International Defense Review. 6 May 2016. Available at: http://www.janes.com/article/60050/usaf-puts-talon-hate-to-the-test

Captain William A. Perkins

graduated in 1994 from Maine Maritime Academy with an Unlimited 3rd Mate's License followed by completion of the Navy's flight training syllabus. Captain Perkins holds a Master's Degree in Strategic Foresight from Regent University and is a graduate of the Joint Forces Staff College. He is designated as P-3 Orion Weapons & Tactics Instructor (WTI) and on his 7 deployments he has flown combat missions in every operational theatre in which the P-3C operates. In 2012, Captain Perkins completed a successful aviation squadron command tour as Commanding Officer of Tactical Air Control Squadron ELEVEN. He recently served as Navigator of the USS George Washington aircraft carrier, homeported in Yokosuka, Japan. He is currently serving as the Maritime Air (FW) including Carrier Operations SME at the Joint Air Power Competence Centre.

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was commissioned through the Spanish Air Force Academy as an Officer in 1992. Following operational and instructional postings in several Units, flying mainly the F-18 Hornet, he completed his Command Tour as the 462 SQN Commander in the Canary Islands. After graduating from the Joint Staff College in Madrid, he was posted as an Air-to-Air instructor at the Tactical Leadership Programme. Among other missions, he joined ISAF as the acting Air Liaison Officer, TACP Commander and Airfield Coordinator for the Spanish Battalion. He returned to the Staff College as an Instructor in 2012 and is currently the Manned Air Defence Subject Matter Expert at JAPCC. Lieutenant Colonel Presa holds a Ph.D. in Linguistics.

Colonel Joseph Speed

graduated from Mississippi State University with a Bachelor of Business Administration Degree in 1992. He has served as an F-16 instructor pilot, flight examiner, flight commander and assistant director of operations. He also has served as a director of operations and squadron commander of flying training and support squadrons. He is a command pilot with more than 2,800 flying hours, including 353 combat hours. He is currently serving as the Combat Air Branch Head at the Joint Air Power Competence Centre.

Beating Brownout

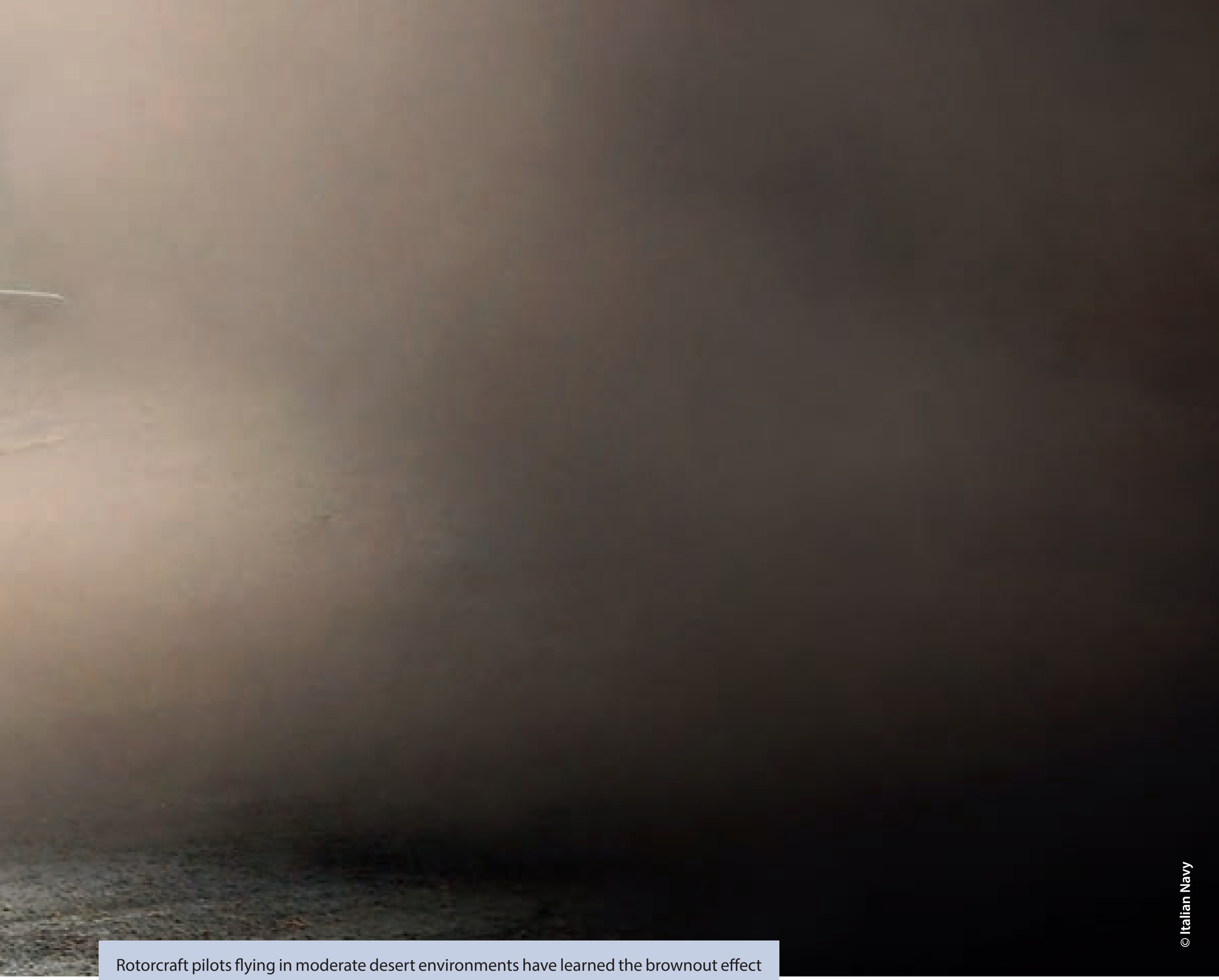
Technology Helps, but Training Remains Key

By Commander Maurizio Modesto, ITA N, JAPCC

Introduction

When I started my helicopter pilot training at Whiting Field (US), I practiced my landings on clean, square, cement pavement. Conditions hardly differed when I made my first operational landings as a Navy helicopter pilot. When I approached a ship's landing spot, my only concern was not dropping my helicopter into the sea. I had no idea that my landings could become more challenging until I started to fly missions in support of Amphibious Operations or Special Operations. In fact, during my first landings on unprepared, non-paved landing zones (LZ), I experienced something I initially considered to be light Foreign Object Damage (FOD), but it was not. During some training with a United Kingdom Navy Squadron, I discovered Army pilots had to deal with this phenomenon every day. They called it 'brownout'. Imagine an approach at night, with little natural illumination, to an unknown landing area in the middle of the desert only defined by given coordinates. Add to that talcum powder dust that begins to pick up at 50 feet and envelops your cockpit and cabin at 20 feet above the ground. The best way to describe a true brownout approach is to ask you to close your eyes at around 25 feet above the ground with near zero air speed and try to land. Believe me, Afghanistan was – in that regard – the nightmare of my Squadron.

Landing in brownout conditions has been described as 'far and away the most dangerous thing you can do as a helicopter pilot', and it is costing the military



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Rotorcraft pilots flying in moderate desert environments have learned the brownout effect during landings can instantly transform unlimited visibility to complete blindness.

significant amounts of money and – more importantly – lives. One pilot described this phenomenon as 'essentially flying a controlled crash into the ground with no outside reference'.[1] The issue of helicopter brownout has long been a known problem, but it has become a really expensive problem for NATO forces during military operations in Afghanistan and Iraq. Since 2002, the US Army alone has lost or damaged 27 helicopters in brownout mishaps. NATO helicopters from all Nations and services have suffered losses operating at unprepared sites in dense, recirculating dust. The US Air Force Institute of Technology stated that the US Department of Defense (DoD) attributes over 100 million USD in total costs per year to brownout mishaps, and it found brownout accounted for 65 per cent of non-hostile fatalities during hover and low speed flight.[2] In the overall Operation Enduring Freedom, the US DoD attributes one third of all helicopter mishaps to brownout. Consequently, strengthening pilot awareness through improved flight displays for low speed manoeuvring is a top priority for all military forces using helicopter support in an effort to prevent brownout mishaps. That is why brownout has recently become a more prevalent research topic than in the past.

The Brownout Phenomenon

Technically speaking, helicopter brownout is the dangerous phenomenon often experienced when performing take-offs, approaches, and landings in dusty environments, where sand or dust particles get swept up in the rotor downwash and obscure the pilot's vision of the terrain. Brownout develops due to the inherent nature of the helicopter rotor system, which takes air in and accelerates it downward at a vector resulting from the angular deflection of the rotor blades. This accelerated air is known as the rotor downwash. During flight at high altitudes, the rotor downwash dissipates easily into the surrounding air. However, as the helicopter hovers near to the ground at relatively low airspeeds, the downwash makes contact with the surface terrain and creates a cushion of air in between the helicopter and the ground. This reduces the air entering into the rotor system and is known as ground effect. The start of brownout is typically expected to begin when the aircraft enters in ground effect (IGE), which occurs at an altitude approximately equal to the diameter of the main rotor.

Rotorcraft pilots flying in moderate desert environments have learned the brownout effect during landings can instantly transform unlimited visibility to complete blindness, i.e. from Visual Meteorological Conditions (VMC) to Instrument Meteorological Conditions (IMC). While this problem is prevalent in dry, dusty, and sandy areas, a similar phenomenon can also occur in snowy conditions and is known as a 'Whiteout'.

Further research on the technical causes of brownout came up with additional factors driving brownout severity.

Rotor Disk Loading. This is the ratio of a helicopter's mass to the lifting area of the main rotor disk, usually expressed in pounds/square inch or kilograms/square meter. A helicopter in a hover must produce a downward thrust equal to the mass of the helicopter, thus the heavier the helicopter, or smaller the rotor disk diameter, the higher the disk loading. Helicopters with higher disk loading produce more thrust and hence faster rotor downwash velocities, and are typically expected to generate more severe brownout as a result.

Rotor Configuration. Despite this principle of rotor disk loading, tandem rotor configurations experience more severe brownout than single rotor helicopters. This particular phenomenon has been further examined by Phillips and Brown, who applied an Eulerian simulation of simplified landing manoeuvres to predict the formation of the dust cloud under different rotor configurations.[3] Their findings showed that tandem rotorcraft, such as the CH-46 'Chinook', generate more dense and longer lasting dust clouds in comparison to the single rotor configuration.

Blade Tip Design. Another factor in brownout may be blade tip design. Pilots of the Leonardo 'Agusta Westland' EH-101 reported that its blade system, developed by the British Experimental Rotorcraft Program (BERP), produces a 'donut effect' of clear air around the aircraft reducing the brownout effect.[4] Though specific causes for the phenomenon are not known, the manufacturer Agusta Westland, attributes the phenomenon to advanced blade tip design of the BERP blades. A similar blade tip design is used for the Lynx helicopter; however, it does not experience the same 'donut' effect. Studies were conducted comparing the UH-60 and the EH-101 to investigate reasons for differing brownout performance with no conclusive evidence found. One possible explanation for this could be related to the airframe design of the EH-101, rather than the blade tip design.

Technical Requirements and Solutions to Brownout

A Research and Development (R&D) push has resulted in technical solutions to mitigate the effects of a Degraded Visual Environment (DVE) on rotorcraft during low-altitude manoeuvring, particularly during landings and take-offs. Based on visual cues indicating drift, height above terrain (HAT), descent rate, ground speed, attitude, slope, terrain features, LZ location, obstacle clearance, and moving obstacle detection, the pilot is provided with more intuitive and salient information, thus increasing aircraft orientation awareness and strengthening decisions for controlling the aircraft. With this new technology, if available, pilots are principally able to hover, land, and take-off helicopters without outside visual references while immediately recognizing non-intentional aircraft movement.

- Low-speed flight symbology already helps prevent crash descents and dangerous drift in dust. US Army Apache pilots use AH-64 hover symbology to make brownout landings, and similar cockpit cues have migrated to US Air Force helicopter cockpits.

- The Rockwell Collins Common Avionics Architecture System (CAAS) in new Chinooks incorporates symbology for the Brownout Situational Awareness Upgrade (BSAU).[5] This program is also part of the UH-60M upgrade to the US Army Black Hawk, and derivative displays will go into the aging US Marine CH-53E and new fly-by-wire CH-53K.

- US Marine MV-22 and Air Force CV-22 tilt rotors have flight path vector displays that allow crews to make brownout landings manually with cues on the hover indicator or automatically using the fly-by-wire hover-hold function.

- Boeing Chinook engineers, meanwhile, claim that the Digital Automatic Flight Control System (DAFCS) in the CH-47F achieves the desired effect at lower cost. With an automatic departure mode, the DAFCS is already credited with saving lives when pilots lost spatial orientation in brownout.

- Brownout initiatives are now looking to integrate see-through infrared sensors with synthetic vision displays. Some tests showed medium-to-long-wave Forward Looking Infra-Red (FLIR) sensors had twice the dust-penetrating performance than electro-optical cameras. The current 3-to-5 micron or 8-to-12 micron FLIRs mounted on attack helicopters for targeting and navigation are essentially still blind in brownout.

- The United Kingdom MoD, in collaboration with Leonardo Company, conducted a research program called All Condition Operations and Innovative

Landing in brownout conditions is dangerous. Brownout mishaps during current NATO missions often cost aircraft and crew lives.

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While waiting for technology that hopefully will vanquish the brownout problem for rotorcraft crews, the most practical way ahead remains robust training.

Cockpit Infrastructure (ALICIA) looking at future designs and configuration regarding cockpit layouts and the Human Machine Interface (HMI). One of the purposes of this program is exploiting ways to assist the aircrew in take-off, approach, and landing operations in the presence of re-circulating sand and dust. ALICIA yielded many innovative ideas concerning a suite of cockpit design concepts and technology solutions to be universally applied across multiple military and civilian aircraft platforms, both fixed wing and rotorcraft.[6]

When implementing technological solutions, it is important to take human factors and cultural mind-sets into consideration. In particular, will organizations recognize the requirement for more intense Instrumental Flight Rules (IFR) training in comparison to regular landing procedures? To make the new technologies seem natural to the pilots, solutions should be intuitive and as easy to use as possible, but acclimation to the new technologies can also be improved through more robust training.

Brownout Training

The helicopter, by nature, is an unstable platform that forces pilots to continuously operate their controls to gain and maintain stability based on visual or other sense references. Helicopter operations such as externals, fast roping, and rappelling require the aircraft to maintain a hover for extended periods of time, and hovering requires an active outside scan and a visual ground reference. Without immediate corrective input to the controls, the position of the helicopter can only be maintained for a very short period of time. Unintentional drift may develop causing the aircraft to strike an obstacle or hit the ground with excessive rate of descent or airspeed.

Although many aspects of helicopter flight can be performed using only an instrument scan, landing and hovering cannot. Standard instrumentation in most of the current helicopter models does not yet provide the fidelity or adequate feedback for drift and height above terrain meaning that pilot inputs are still essential to keep control of those fundamental parameters during landings and take off. Even the Automated Flight Control Systems (AFCS) available in some legacy airframes still rely on the pilot's hands-on control.[7] All of this makes the aircrew particularly susceptible to brownout.

As long as the technical solutions mentioned above have not yet been introduced and sufficiently proven their reliability, pilot training remains indispensable when it comes to mitigating brownout effects. Most NATO nations, therefore, have improved their helicopter pilot training by incorporating different landing techniques and skills addressing brownout situations. Respective training objectives are now integrated into military helicopter pilot student guides and defined in greater detail in national flight training instructions. In particular, they contain procedures and indicators for pilots to determine – even in the last moment – whether it is recommended to execute a shallow approach rather than a steep approach in order to avoid or mitigate brownout. The different landing and take-off techniques to limit the brownout effect are also described in an extensive Technical Report published in 2012 by the NATO Research and Technology Organisation (RTO).[8] Among other manoeuvres, these landing techniques are part of the simulated and live training requirements for all NATO helicopter pilots prior to joining an operation.

Conclusion

Brownout mishaps still cost NATO in aircraft and crew lives in ongoing conflicts. However, troops are being withdrawn from Afghanistan and Iraq to areas where brownout is less probable. That is why investments in cockpit and sensor technology addressing DVE conditions will probably be de-prioritized in favour of other pressing issues competing for the same limited defence budgets. More importantly, when helicopter units do not deploy they spend less time in the air, training opportunities become scarce, and skills consequently degrade.

However, while waiting for technology that hopefully will vanquish the brownout problem for rotorcraft crews, the most practical way ahead remains continuous training. Apart from improved cockpit symbology, better crew training has proven to mitigate the risk related to brownout. Considering training is therefore even more vital than technology. The Alliance and Nations should not wait until the next conflict emerges, but invest permanently in pilot training specifically addressing the brownout phenomenon. ●

1. Frank Colucci. 'Beating Brownout'. 1 Apr. 2010. Online at: http://www.aviationtoday.com/2010/04/01/beating-brownout/
2. Air Force Institute of Technology. 'Solutions Analysis for Helicopter Brownout'. Oct. 2006. Online at: http://dtic.mil/dtic/tr/fulltext/u2/a468063.pdf
3. Catriona Phillips, Richard E. Brown. 'Eulerian Simulation of the Fluid Dynamics of Helicopter Brownout'. 11 May 2010. Online at: https://pure.strath.ac.uk/portal/files/514923/strathprints027438.pdf
4. US Army Aviation and Missile Command, Army – NASA Rotorcraft Division – Army Aeroflightdynamics Directorate (AMRDEC). 'Rotorcraft Downwash Flow Field Study to Understand the Aerodynamics of Helicopter Brownout'. Oct. 2008. Online at: https://rotorcraft.arc.nasa.gov/Publications/files/Wadcock_AHS2008.pdf
5. Rockwell Collins. 'Common Avionics Architecture System'. Online at: https://www.rockwellcollins.com/Products_and_Services/Defense/Avionics/Integrated_Cockpit_Solutions/Common_Avionics_Architecture_System.aspx
6. ALICIA – All Condition Operations and Innovative Cockpit Infrastructure. 'D-FPR: Final PublicReport'. Online at http://www.alicia-project.eu/CMS/images/stories/ALICIA-RPT-AWUK-WP0-0206_D-FPR_Issue_1.pdf
7. Stars and Stripes. 'Slew of military helicopter deaths raises question of whether budget cuts endanger troops'. Online at: http://www.stripes.com/slew-of-military-helicopter-deaths-raises-question-of-whether-budget-cuts-endanger-troops-1.390587
8. NATO. 'Rotary-Wing Brownout Mitigation: Technologies and Training'. Ref. AC/323(HFM-162)TP/400. Jan. 2010. Online at: www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA557615

Commander Maurizio Modesto

joined the Italian Navy in 1988 and completed flight training with the US Navy in 1992. In his career he has flown 5,000 hours mostly in support of amphibious and special forces operations and he has been an instructor pilot in the SH-3D and EH-101. He has participated in all major operations including Somalia 2 and 3, Kosovo and Afghanistan. From 2000–2002 he was an exchange pilot with the Spanish Navy for the SIAF (Spanish Italian Amphibious Force). From 2010–2011 he was the EH-101 Helicopter Squadron Commander in Herat (Afghanistan). From 2011–2014 he served as a staff officer at the Italian Naval Air Fleet Command in Rome. He is currently stationed at the JAPCC in Kalkar, Germany, as the Joint Personnel Recovery, Littoral and Special Operations Subject Matter Expert.

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A Tactical Coordinator aboard the P-8A Poseidon displays some of the ISR sensors and networked systems of the new airframe.

Enabling Maritime ISR through the 'Family of Systems'

By Captain William A. Perkins, USA N, JAPCC

Introduction to Maritime ISR

Maritime Patrol has existed since the early days of aviation and has been a critical part of nearly every NATO operation. Beginning with visual detection of naval task groups in the early part of World War II, the tactics for conducting surveillance at sea have evolved in concert with the sensors and the ability to communicate that intelligence in a timely manner to the users who need it. Evolutions in sensors and systems continue to change the way platforms at the Maritime Component level perform joint functions.

This article will discuss the Intelligence Surveillance Reconnaissance (ISR) capabilities of new Maritime Patrol Aircraft (MPA) platforms (the P-8A Poseidon and the MQ-4 Triton) and review how they link together as a network-enabled system to share not only intelligence, but also functions so they can operate together as an ISR team. This new way of integrating traditional MPA systems and functions for intelligence gathering will have an impact on ATP-102 (NATO Procedures for Maritime ISR), which is currently under development.

History of Maritime Patrol, Maritime Surveillance, and Maritime ISR

With the 1990s' decrease in Air Power Contribution to Maritime Operations (APCMO)[1] functions, such as Anti-Submarine Warfare, many MPA transformed into ISR platforms. These platforms gained improved electro-optics and imaging radar systems, coupled with enhancements to satellite communication and the ability to transmit live video and still images to other elements of the joint force. Consequently, these aircraft began operating not only as Maritime Surveillance platforms to keep track of naval contacts of interest, but as an integral part of the overall Joint ISR capability. As the P-3C Orion (for decades a workhorse in many nations' MPA and ISR systems) reaches end-of-service-life, many NATO nations are rethinking the process by which Maritime ISR is conducted and migrating away from a platform-based philosophy to a system-of-capabilities model for intelligence gathering.

Maritime Patrol is commonly understood to encompass certain aspects of maritime intelligence gathering. An MPA can execute the full cycle of functions in the traditional Find, Fix, Track, Target, Engage, and Assess (F2T2EA) concept. Whereas some newer MPA are being built without kinetic capability (lacking either torpedoes or anti-ship missiles or both), their functions are limited to Maritime Surveillance (only FFT and A). Examples include the Polish Bryza and the common variants of the ATR-72 (ITA and TUR) and CASA 235 (ESP, IRE and TUR).[2]

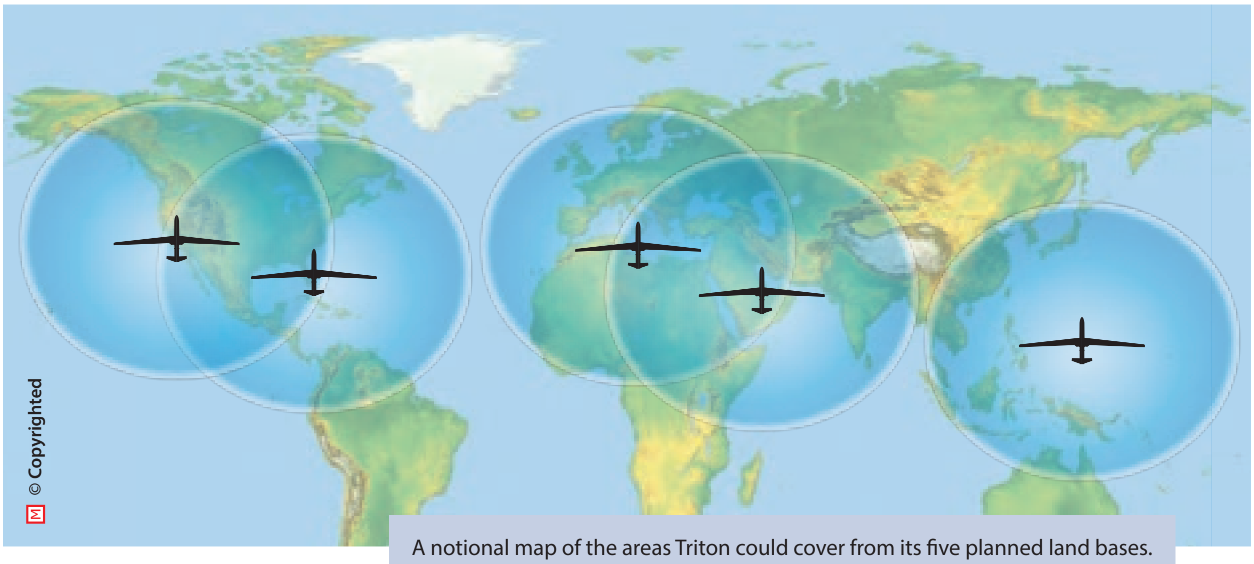
Furthermore, many NATO nations modified their traditional MPA (P-3C Orion and MR2 Nimrod for example) with different sensor types dedicated to other collection disciplines such as Signals Intelligence (SIGINT) or its subset Communications Intelligence (COMINT), therefore precluding traditional MPA functions of naval target engagement. The US Navy previously had two complete squadrons of SIGINT-modified Orions, designated the EP-3 Aries, which saw more service in overland joint support roles than it did performing traditional overwater intelligence missions. The Aries, like many of its SIGINT counterparts in NATO, was not capable of carrying weapons and was relegated solely to an ISR role. To manage the growing demand on a dwindling number of airframes, in 2005 the US relocated Fleet Air Reconnaissance Squadron (VQ) 2, from Naval Air Station Rota, Spain, and in 2012 decommissioned the squadron.[3] The Aries is approaching the end-of-service-life rapidly, and its intelligence capabilities will migrate to a set of both manned and unmanned replacement platforms rather than a single airframe.

Similarly, the P-3C Orion is also approaching end-of-service-life. At its height, variants of the Orion were flown by nine Alliance members, as well as eleven other non-NATO nations. Three NATO Nations have planned to migrate to the P-8 Poseidon Multi-Mission Aircraft (USA, GBR, NOR), while others have elected additional life extensions in lieu of replacement. But all have conducted significant upgrades to ISR systems (sensors and communications capability) as part of either replacement or life extension.

New MPA ISR Platforms within NATO Nations

1. The MQ-4 Triton. The MQ-4 Triton is a derivative of the RQ-4 Global Hawk airframe with sensors specifically designed for intelligence gathering in the maritime environment, such as the AN/ZPY-3 Multi-Function Active Sensor (MFAS) with a 360° field-of-regard active electronically scanned array (AESA) radar antenna.[4] Furthermore, the payload comprises an electro-optical/infrared (EO/IR) sensor, automatic identification system (AIS) receiver, and electronic support measures (ESM). The AN/ZLQ-1 ESM uses specific emitter identification (SEI) to track and detect emitters of interest. The MTS-B multispectral targeting system performs auto-target tracking and produces high-resolution imagery in multiple fields-of-view and full motion video.[5] Communications relay and Link 16 integrate the Triton into the joint fight.[6] With performance capabilities similar to the RQ-4 Global Hawk, which is the air vehicle of NATO's Alliance Ground Surveillance (AGS) system, its long endurance and high altitude make it ideally suited for those traditional maritime intelligence functions of 'detect' and 'track' without consuming precious flight hours of manned surveillance aircraft which are needed for the kinetic end game. The Triton will be capable of sharing information in real time with both its manned partner, the P-8A Poseidon and with the NATO AGS Ground Station, allowing it to seamlessly integrate into NATO's Joint ISR system. Eventually, the US is planning to purchase 68 Tritons.[7]

2. The P-8A Poseidon. The P-8A Poseidon not only brings all of the anti-submarine and anti-shipping capability of the Orion, but also expands significantly on



A notional map of the areas Triton could cover from its five planned land bases.

its ISR and joint battlespace operations potential. In a departure from the Orion, all Poseidons will have Link 16, as well as upgraded electro-optics and imaging radar systems. In addition to the maritime imaging radar mounted in the nose, a future plan for the Poseidon is to carry the externally mounted AP/ANY-10 MTI imaging radar system (upgrade from the P-3's Littoral Surveillance Radar System – LSRS), which adds both an overland and maritime MTI capability approaching the fidelity provided by the US Joint Surveillance and Target Attack Radar System (JSTARS). But these sensors are not much more advanced than those on the more modern P-3s; the true advance in the Poseidon is the ability to rapidly exchange and share information internally among the crew and externally among joint partners.

The US is planning to acquire 117 P-8A, with nine being purchased by GBR.[8] Norway is exploring six Poseidons to replace their aged P-3 Orions. Outside NATO, Australia and India (eight planned by each) have already received their first airframes and interest is being expressed by many other nations as well.[9] The Poseidon's ability to integrate into the respective nation's Joint intelligence system while providing real-time intelligence to afloat commanders, as well as real time targeting information to sea-based strike aircraft, is dramatically improving the link between maritime intelligence and aircraft carrier or amphibious operations.

The 'Family of Systems' Concept

The 'Family of Systems' concept is a perspective on ISR that changes from a platform-centric view to one based on capabilities spread over multiple platforms. This is an attempt to better integrate strategic ISR collection capabilities with those focused on the operational and tactical levels, as well as to integrate those platforms that can only perform some of the F2T2EA functions with those able to execute the remainder. The key to this family concept is interoperability and integration; the ability to share information.

The Triton program manager highlighted the relationship between the Triton and Poseidon in this way: 'Say the Triton is out doing a mission somewhere in the world and defines a target of interest, and we decide we want to explore that further, you have the perfect scenario where you can stay on target, then call in or direct a P-8 to that area to do more work with different sensors. It takes the best capabilities of each and puts them together in the first manned/unmanned programme of its kind.'[10] Future upgrades to the Poseidon envision the ability not only to target the enemy with the Poseidon's own weapons, but also the ability to manage off-board sensors and weapons.[11]

The US Navy is even looking at the potential of adding in a carrier-based system to this family, linking

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A notional depiction of an MQ-4 Triton and P-8A Poseidon operating together providing Maritime intelligence for the Maritime Component Commander.

the manned, land-based P-8A Poseidon with the Triton and the Unmanned Carrier-Launched Airborne Surveillance & Strike (UCLASS) drone.[12] The UCLASS is a proposed, but not yet approved, unmanned carrier system that will serve as a tanker for carrier-based fighter aircraft and may also be fitted with ISR sensors to aid in maritime intelligence functions. However, the first iteration of the UCLASS, called the MQ-25 Stingray, will not yet include a strike capability.

The US Navy is electing to deviate from typical unmanned platform organization. Instead it plans to co-locate the Triton and Poseidon squadrons and co-man them. Tritons will ideally be operated by Poseidon aircrew serving in a subsequent 'flying' tour of duty. This allows a unique perspective into manned and unmanned teaming, as the operators will be versed in the tactics and sensor capabilities of the other in a unique way, having flown the Poseidon on multiple combat deployments prior to arrival at VUP-19 (the Triton squadron established in October 2016 in Jacksonville, Florida, and co-located with six Poseidon squadrons).[13]

Recommendations for the ATP-102 Writing Team

In 2014, Allied Maritime Command highlighted a growing disconnect between the Maritime Component and the Joint Intelligence (JINT) process and requested a study be conducted into the efficient use of future Maritime ISR. In October 2016, Allied Command Transformation accepted this request and stood up a writing team to develop ATP-102, NATO Procedures for Maritime ISR, in an effort to codify the link between maritime intelligence collection and the Joint ISR process.

As this article outlined, from a sensor perspective the future for Maritime Intelligence is likely not platform based. In fact, future Maritime Patrol Aircraft, including the Poseidon and Triton, will likely be directed and co-ordinated, in part, by the Joint Force Commander's ISR collection management staff as often as they are managed by the Maritime Component Commander. Although this is done to some extent with ISR variants of MPA today, it is likely this role-sharing will grow in scope and complexity as new sensors and new MPA are developed. As these aircraft are capable of many

The Unmanned Carrier-Launched Airborne Surveillance & Strike (UCLASS) drone is a proposed, but not yet approved, unmanned carrier system for the US Navy that will serve as a tanker for carrier-based fighter aircraft and may also be fitted with ISR sensors to aid in maritime intelligence functions.

simultaneous yet different functions both internal and external to the intelligence gathering process, the mechanism by which these platforms are exploited must be mutually beneficial to both the JFC's Joint ISR requirements and the needs of the Maritime Component Commander.

As ATP-102 takes form, the writers should not discount the operational role of intelligence. Platforms that are principally intelligence gatherers, such as the Triton, must have a role supporting the Maritime Component in addition to serving in the Joint intelligence role. Multi-mission platforms, such as the Poseidon, which are capable not only of intelligence gathering to meet strategic and operational needs but also of the kinetic end game at the tactical level, must continue to serve both masters as well. The final version of the doctrine should inform commanders how best to exploit the existing Joint ISR procedures for Maritime operational level needs and codify how intelligence gathered at the tactical/operational level by various maritime platforms (above, on and under the sea) is pushed up into the joint process for multi-component exploitation. ●

1. As defined in AJP 3.3.
2. Turkey is exploring both an ASW and ASUW model of their P-72 (ATR-72 derivative). Available online at: http://www.defenseindustrydaily.com/219m-for-10-turkish-asw-aircraft-0905/
3. Fleet Air Reconnaissance Squadron TWO [VQ-2] 'Sandeman'. Global Security. Available online at: http://www.globalsecurity.org/military/agency/navy/vq-2.htm
4. Northrup Grumman. 'AN/ZPY-3 Multi-Function Active Sensor (MFAS)'. Available online at: http://www.northropgrumman.com/Capabilities/MFAS/Pages/default.aspx, accessed 15 Feb. 2017.
5. NavalTechnology. 'MQ-4C Triton Broad Area Maritime Surveillance (BAMS) UAS, United States of America'. Available online at: http://www.naval-technology.com/projects/mq-4c-triton-bams-uas-us/, accessed 15 Feb 2017.
6. Northrup Grumman MQ-4 Triton. Available online at: http://www.northropgrumman.com/Capabilities/Triton/Pages/default.aspx
7. Ibid.
8. Naval Technology. 'P-8 Poseidon'. Available online at: http://www.naval-technology.com/projects/mma/
9. Boeing P-8. Available online at: http://www.boeing.com/defense/maritime-surveillance/p-8-poseidon/index.page
10. Baker, Berenice. 'US Navy's Triton UAS – Poseidon's perfect partner'. 10 Nov. 2014. Naval Technology. Available online at: http://www.naval-technology.com/features/featureus-navys-triton-uas-poseidons-perfect-partner-4429204/
11. Laird, Robbin and Timperlake, Ed. 'Visiting Jacksonville Naval Air Station: The Family of Systems and Naval Air Transformation' 26 May 2016. Second Line of Defense. Available online at: http://www.sldinfo.com/visiting-jacksonville-naval-air-station-the-family-of-systems-and-naval-air-transformation/
12. Freeburg, Sydney. 'Triton, Poseidon, & UCLASS: The Navy's ISR Balancing Act', 1 Oct. 2014. Breaking Defense. Available at: http://breakingdefense.com/2014/10/triton-poseidon-uclass-the-navys-isr-balancingact/
13. Ibid 11.

Captain William A. Perkins

graduated in 1994 from Maine Maritime Academy with an Unlimited 3rd Mate's License followed by completion of the Navy's flight training syllabus. Captain Perkins holds a Master's Degree in Strategic Foresight from Regent University and is a graduate of the Joint Forces Staff College. He is designated as P-3 Orion Weapons & Tactics Instructor (WTI) and on his 7 deployments he has flown combat missions in every operational theatre in which the P-3C operates. In 2012, Captain Perkins completed a successful aviation squadron command tour as Commanding Officer of Tactical Air Control Squadron ELEVEN. He recently served as Navigator of the USS George Washington aircraft carrier, homeported in Yokosuka, Japan. He is currently serving as the Maritime Air (FW) including Carrier Operations SME at the Joint Air Power Competence Centre.

Joint Terminal Attack Controllers from the US Air Force direct two A-10 Thunderbolts II during a training exercise at Adazi Training Area, Latvia. JTACs from various units around the Air Force joined exercise Saber Strike 2015 to work with ally and partner nation counterparts to provide precise and directed aircraft support to Army units participating in the exercise.

The Rise of Close Air Support after World War II

Did the US Army and US Air Force Inter-Service Rivalry Benefit Close Air Support?

By Major Paul R. Andrews Jr., Naval Post Graduate School

Introduction

On a cold, clear night in Afghanistan in November 2011, an Air Force AC-130 Gunship and an AH-64 Apache check in with the Army ground party they are to work with. Both aircraft are providing close air support (CAS) utilizing the latest in sensor technology and accurate weaponry. The ground parties are glad to hear from the crew. They are intimately familiar with the capabilities they bring, having counted on the Air Force for support with previous missions. The aircrew provides the Joint Terminal Attack Controller (JTAC) with their mission number, call sign, altitude, ordnance, estimated time on target and station time, available sensors and air-to air refuelling control time. On this night, the Air Force AC-130 Gunship and AH-64 Apache provide CAS for a direct-action mission to capture a high value individual (HVI). The mission consists of a safe infiltration for the friendly ground forces by helicopter airlift, fire support and sensor coordination between all air and ground assets, and capture of the HVI. The safe exfiltration of the ground forces to their Forward Operating Base (FOB) culminates a successful mission.

The natural professionalism and confidence of each military asset begs one to wonder, was is it always this way? Unfortunately, no. The history of CAS within the US military is one of sometimes bitter inter-service rivalry, but the lessons learned benefit US and NATO forces in the field today, as this article will illustrate. Within the remainder if this essay, the use of the terms 'Army' and 'Air Force' will always refer to the US military unless stated otherwise.

Primacy of CAS – The Struggle for Roles and Mission

When the US Air Force became a separate branch of the military in 1947, it anticipated taking all or most of the air functions from the US Army.[1] The Key West agreement of 1948 further identified the service roles and missions of the Air Force.[2] The Army and Air Force would agree to cooperate as a team on joint missions and the Air Force would provide the Army with airlift and CAS. The CAS matter in particular would lead to tension between the Army and Air Force, in regards to who would perform the role and how it would be performed. The Army was unhappy with the CAS provided by the Air Force during the Korean War (1950–1954) and did not agree with the centralized command and control concept the Air Force wanted. The Army desired to create its own air force, and the 1950s saw an increase of Army aviation comprised of 668 light airplanes, 57 helicopters, and the birth of the airmobile concept.[3]

From 1948 until 1956, multiple directives and agreements were published to address the scope, roles, and mission sets for both the US Air Force and Army. However, these memorandums did not address the concerns and disagreements. In 1957, Secretary of Defense Charles E. Wilson issued Directive 5160.22, which stated the Army would not provide aircraft to perform the following functions: 1) strategic and tactical airlift, 2) tactical reconnaissance, 3) interdiction of the battlefield, 4) CAS. More importantly, the Air Force was to meet reasonable requirements as specified by the Army and use appropriate resources.[4] This statement led to further tension, since the Air Force believed the use of CAS by the Army was redundant and overlapped in effort and execution.[5] In particular, the Air Force did not approve the use of helicopter gunships for CAS by the Army and preferred to control them as well.[6]

In the 1960s, both services put pressure on US Secretary of Defense Robert S. McNamara to provide for a military force structure with clearly defined roles to

A Joint Tactical Air Controller from the Latvian armed forces, marks a drop zone with smoke during Exercise Northern Strike 2014 near Rogers City, Michigan, on 5 August, 2014.

meet operational requirements.[7] Unfortunately, the directives he issued to resolve the dispute of roles and missions did not address the Army's concerns regarding better CAS provided by the Air Force, nor did it address the Air Force's concerns about the Army's ever increasing expansion in aviation. Secretary McNamara preferred to let the Chiefs of Staff from the Army and Air Force develop the requirements of each service and send them forward for consideration.[8]

The Vietnam War would see the emergence of airmobile operations by the Army with helicopters equipped to provide CAS with an agile, small footprint and the Air Force's insertion of Special Air Warfare with the use of light attack aircraft such as the A-1, A-26 and A-37. President John F. Kennedy's 'Flexible Response' strategy and message to each service was clear: develop special force capabilities in unconventional warfare to counter enemy forces. However, compliance with this political guidance was hampered by both the Army and Air Force's persistent habit of fighting in a more conventional manner. The Army was still trained and equipped for the conventional warfare that was successful in World War II, and continued to prefer fighting guerrilla forces with the concept of attrition. The Air Force favoured conventional bombing of North Vietnam with little emphasis placed on countering insurgency in South Vietnam.[9]

Inter-Service Disagreements on CAS

The US Army and Air Force differences concerning CAS originated from World War II and continued into Vietnam. For the Army, the concerns about the Air Force providing CAS centred on the types of aircraft employed and the responsiveness of the Air Force. But this was not the only differing issue; command and control continued to be a focal point of opposing opinions.

The Air Force envisioned a multi-role fighter and attack aircraft capable of speeds that could avoid surface-to-air threats and a weapon payload flexible enough to perform multiple roles.[10] The Army, however, desired an aircraft with adequate loiter time to support ground forces from a lower altitude and with better bombing accuracy; speed was not a priority.[11] The other outstanding criticism was the slow response time for immediate fire support requests from ground forces. Because of the limited number of available CAS assets, in particular the AC-47, the response was sometimes as

much as 90 minutes.[12] The use of army helicopter gunships helped to reduce the gap, along with staging forces on alert to provide CAS as required. However, while the Air Force claimed success in CAS operations, the Army viewed the close air fire support of UH-1 helicopters as a mitigation of slow response times, not as a solution to the CAS issue.[13]

Differences in command and control also dated to World War II. The US Air Force viewed the success of the combined air and ground campaign in North Africa with the Royal Air Force (RAF) operating under centralized control as the desired application of air resources. The Army disagreed, believing CAS was neglected in favour of air interdiction and air superiority missions.[14] The sample of centralized control was too small to indicate a clearly defined, successful way of controlling air assets. The Vietnam War would see the differences in command and control unresolved as the Army and Air Force pursued their own interests. The Air Force wanted all air power assets operating under the Tactical Air Control System (TACS), while the Army favoured the use of organic air power assets under the control of ground forces, which it felt provided quicker response time and support.[15]

Doctrine Development

With different views on CAS and command and control by the Army and Air Force in Vietnam, developing doctrine was imperative. The early doctrine development of CAS originated with the combat experiences of the Army and Air Force pioneers during World War II, the Korean War, and the Vietnam War.[16] These conflicts cultivated tactics, techniques, and procedures (TTP) that would ultimately develop the framework for the doctrinal guidance in use today. For example, some of the same TTP gained from aircrew flying the first gunship, the AC-47 in Vietnam, are still practiced today when conducting CAS in the AC-130U/W.

Developed out of the successes and failures of the past, the US Joint Publication 3-09.3 on CAS clearly defines CAS as the air action by fixed and rotary wing aircraft 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.[17] In particular, this doctrine excludes a centralized air command and control concept regarding CAS that was already ill-suited for the needs of the Army in Vietnam.

A USAF JTAC uses a radio to communicate with pilots of A-10 Thunderbolt II aircraft during a CAS training mission at the Nevada Test and Training Range on 23 September, 2011. JTACs perform proficiency training with USAF Weapons School students during the CAS phases of the curriculum.

Lessons Learned

The rise of CAS and air power benefitted from the Army and Air Force inter-service rivalry, which peaked during the Vietnam War. Competing differences in aircraft, command and control, and clear, defined mission roles proved troublesome during the Korean and Vietnam Wars. The Air Force and Army worked through each services' requirements and goals to clearly define CAS doctrine and employ both fixed and rotary wing CAS effectively and efficiently in combat. Today, the US military and NATO partners have enhanced the effectiveness of CAS and joint force application with officers attending joint military educational institutions and participating in joint force exercises. A key lesson learned from the Vietnam War regarding CAS was the need to reduce the time required to get support to ground forces in contact with the enemy.

The battlefield today contains multiple air players providing redundancy and overlapping CAS competencies to better support ground forces. A typical combat mission for a crew of an AC-130 Gunship, a low-density, high-demand asset like the AC-47 was in Vietnam, could provide CAS for a US Army, British, or Canadian special forces ground unit or even a conventional ground unit involved in a troops in contact (TIC) situation. In the air stack today, one can expect to find an AC-130, an AH-64, a U-28, an RPA, an A-10 and possibly a B-1 or B-52 Bomber all being controlled by a JTAC.[18] What is important to emphasize in the history of the inter-service rivalry between the Army and Air Force is that the different perspectives that existed between both branches of the military each had merit, and the more each service worked with the other, the more CAS improved.

The importance of joint air operations has never been more understood than it is now. Advancing technology in RPAs performing ISR and CAS roles has permitted an increased CAS extension around the globe. While command and control can always be improved, it is clear that CAS will continue to evolve for the better, supporting ground forces with on call, quick, precision fire support on the battlefield. ●

1. Ian Horwood, 'Interservice Rivalry and Airpower in the Vietnam War', Combat Institute Studies Press, 2006.
2. Michael A. Hall. 'Defense Policymaking: The Post-Cold War Roles and Missions Debate'. Naval Postgraduate School Monterey CA, 1993.
3. Andrew F. Krepinevich. 'The Army and Vietnam'. The John Hopkins University Press, 1986.
4. Alfred Goldberg and Lt Col Donald Smith. 'Army-Air Force Relations: The Close Air Support Issue'. RAND Corporation. Santa Monica, California. R-906-Pr. Oct., 1971.
5. Ibid 1.
6. Ibid 1.
7. Ibid 2.
8. Ibid 1.
9. Ibid 1.
10 John Schlight. 'Help From Above: Air Force Close Air Support of the Army 1946–1973'. Washington, D.C.: Air Force History and Museums Program, 2003.
11. Ibid 1.
12. Ibid 1.
13 Ibid 1.
14 Ibid 4.
15 Ibid 1.
16 Ibid 1.
17 Lt Col Walter Kross. 'Joint Tactics, Techniques and Procedures for Close Air Support (CAS)'. Online at http://www.globalsecurity.org/military/library/policy/dod/doctrine/jp3_09_3.pdf. Accessed 12 Nov., 2016.
18. 'Forward Air Controller (FAC)' would be the official NATO term, according to AAP-06 Edition 2016 (NATO Glossary of Terms).
19. The mission of the Naval Postgraduate School is to provide relevant and unique advanced education and research programs to increase the combat effectiveness of commissioned officers of the Naval Service to enhance the security of the United States. In support of the foregoing, and to sustain academic excellence, NPS and the Department Of Navy foster and encourage a program of relevant and meritorious research which both supports the needs of Navy and Department of Defense while building the intellectual capital of Naval Postgraduate School faculty.

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No Fair Fights

The Effects of Hybrid War, Disinformation, and RPA Automation on NATO Air Power

By Lieutenant Colonel Carlos Presa-Diaz, Ph.D., ESP AF, JAPCC
By Lieutenant Colonel Martin Menzel, MBA, DEU A, JAPCC

The monopoly of violence is one element that confirms the statehood of modern nations. By agreeing to allocate ways and means to exert and control violence, the society also defines red lines: The legitimate rules for the use of force, establishing norms and values for a fair fight.

Introduction

Russia's recent behaviour and actions are often referred to as 'hybrid warfare'. Although this concept continues to enjoy widespread popularity in both scholarly and policy circles, its utility as an analytical tool is heavily contested.[1] Many sceptics argue the capabilities and methods used by Russia or other contemporary actors are not new or unique.[2] However, changing dynamics within the international environment make this type of warfare look different. It looks as if old tools have been reinvented and used in innovative ways to bring to bear a new kind of pressure on an opponent, to achieve faster and sometimes more vicious political goals. Hybrid warfare is simply the increased level of blending between conventional and unconventional forms of conflict, which are characterized by agility and adaptation – for instance through technological means – in an attempt to achieve decisive effects on the physical and psychological battlefield.[3]

Russia's hybrid methods have been an effective and sometimes surprising mix of military and non-military, conventional, and irregular components that can include all kinds of instruments such as cyber and information operations. None of the single components are new; it is the combination and orchestration of different actions that achieves a surprising effect and creates ambiguity. This makes an adequate reaction extremely difficult, especially for multinational organizations that operate on the principle of consensus.[4]

A primary function of the Alliance's strategic communications is to express the consistency among rules, norms and values of our society with military goals and effects. This includes especially respecting the provisions of the International Law of Armed Conflict (LOAC) as well as the Universal Declaration of Human Rights. So it can be expected that opponents will attempt to discredit the exertion of violence as contrary to the rules of our nations. If an adversary actor cannot achieve conventional superiority in a conflict, they have the option of challenging our adherence to the rules and raising moral/ethical questions. Hybrid tactics, including spread of disinformation, may allow the opponent to create ambiguity of intent and attribution, and therefore discredit any political or military NATO response.

What if the enemy takes advantage of increasing autonomy and automation to use his weapon systems against friendly targets in a non-attributable manner? What if he even manages to hack automated friendly weapon systems to employ them against friendly or other non-intended targets and blame us? Non-attribution and disinformation aspects of hybrid warfare have the potential to bring NATO much closer to the red lines, with particular potential impact on NATO's most significant asymmetric advantage – air power.

Hybrid Warfare and the Red Lines

While combining violent and nonviolent means to achieve goals is an age-old phenomenon, the flexible and swift coordination of these various means with current targeting methods can be considered novel features of modern hybrid warfare. The key targets for hybrid operations are vulnerabilities or weaknesses in any vital part of the target country's society.[5] These vulnerabilities could include the red lines set by this society's norms and values. The red line concept

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Without a remote pilot, highly lethal weapon systems equipped with artificial intelligence mechanisms for platform orchestration may operate independently of a kill chain, delivering any type of weapon on an automatic, pre-programmed vector.

applied to a nation in conflict defines the behavioural boundaries of its members acting as a whole. It may also refer to a point of no return that would generate a different strategic context, or a new, undesired military, economic, or diplomatic framework.

In hybrid war it is nearly impossible to say when the actual fighting or organized violence that is war in its classic form begins. One of the core ideas of hybrid warfare is that it intentionally blurs the distinctions between the neatly separated Western categories of war and peace, and civilian and military operations. This blurring is achieved by utilizing a wide variety of means, both violent and nonviolent, military and civilian, in a carefully planned way without unnecessarily breaching the threshold of war, even if the level of escalation varies.[6]

While in a grey area of no uniforms, no observable presence and no rules in all domains and spectrums, each hybrid action will more or less adhere to a conventional military commander's intent, but with a certain degree of independence. In other words, the hybrid forces maintain a portion of their activities beyond the conflict's red lines while targeting a country or an alliance for the benefit of a visible, politically recognized third party that pretends not to be crossing the red lines. For this reason, the effect of hybrid operations is double: First, they create uncertainty due to the difficulties of identifying, labelling, and attributing these hybrid actions. Second, they raise the possibility of generating friction inside the targeted society, which might even prevent it from taking decisive action against the hybrid threat, including with its conventional warfare potential.

NATO Air Power and the Red Lines

Air Power has long been NATO's (and more specifically the United States') asymmetric advantage[7]. No opponent has matched these capabilities, and anyone tempted to challenge NATO easily identified Air Power as a target for hybrid activities, such as cyber and electronic warfare as well as disinformation. These subjects have been analysed in the three most recent

JAPCC conferences. First, in 2014, a Future Vector was defined to sustain that asymmetric advantage. In 2015, the conference addressed a shortfall in explaining Air Power's role from the Strategic Communications perspective. Finally, in 2016, participants examined a degraded environment, including various factors affecting Air Power.

Air Power is a formidable capability but restrained to operate within the moral and ethical red lines tied to the expectations of civilized societies. Other actors exploit this fact through the use of disinformation. For instance, they might try to characterize NATO Air Power as ruthless aggression, as seen in Afghanistan. Although the International Security Assistance Force (ISAF) operated under careful rules of engagement, a constant Taliban disinformation campaign successfully leveraged popular anti-ISAF sentiments by falsely blaming an exaggerated number of civilian casualties on ISAF air strikes. This led to command decisions that restricted ISAF air and ground firepower even further, shifting the red lines for their employment to the right while accepting higher risk for their own troops.[8] In other words, the Alliance constrained itself to assume higher degrees of risk to avoid the perception of surpassing its legal and moral thresholds. Other forms of disinformation might be used by an adversary hybrid actor to distract from its own aggressions and the collateral damage inflicted, especially if clear attribution can be prevented.

The evolution of advanced conventional warfare capabilities leads to systems with ever longer ranges and higher velocity. However, until present, humans in the loop have dealt with war machinery to maintain it within the envelope defined by the LOAC. In most cases, humans are co-located with platforms, triggers, and communication systems to conduct operations. The reins of command guarantee that Air Power remains both controlled and effective through distribution of responsibilities and decision authority. But a new generation of 'fire and forget' weapons, based on increasing autonomy and automation through artificial intelligence, has arrived. Within NATO doctrine, the 'fire and forget' concept still includes several preconditions for weapons release, among others: a clear avenue of fire, a sorted target, and a clearance to engage. However, a non-attributable, hybrid warrior can easily choose to live outside those boundaries and use the systems without such preconditions.

Unleashed Machines

Science fiction frequently depicts autonomous machines eager to spark a trend of destruction by themselves. Highly lethal weapon systems incorporating artificial intelligence mechanisms for platform orchestration may be designed to operate independently of a kill chain. The Find, Fix, Track, Target, and Engage process would happen away from human restraints, and this self-healing and self-learning set of machines (the dynamic version of the land or sea mines) may populate the third dimension of any operational area.

This concept goes beyond employing Remotely Piloted Aircraft (RPA), where the operator and the weapon have a legal team attached to validate the engagement with lethal payloads after labelling the target. The cyber-orchestration of these elements and their dynamic synchronization through different link features may generate a formidable threat that does not need the physical presence of the human enemy. Unmanned vehicles may be operated to fly and deliver any type of weapon even on an automatic, preprogrammed vector enjoying covertness, flexibility, range, and air defence gaps.

The basic political, legal, and technological challenges NATO has with regard to Air Policing against unmanned aircraft were described in JAPCC Journal Edition 23.[9] It is not difficult to imagine the strong effects that cyber orchestration of an autonomous, unidentified swarm of aggressive adversary aerial vehicles would create in the target society. In addition to scaring civilians, it might paralyze political or military decision makers, who will have a hard time deciding on counter measures in accordance with established red lines, rules and values. If the origin of the threat and the threat itself are impossible to label, and the machines apply their patterns of logic to deliver power outside the red lines of accepted rules and values, then the population will demand information and protection from this faceless enemy.

Conclusion

Current generations in most countries have not lived through a war. Most modern nations abide by the rules of violence exertion and control. But the threat of hybrid war that exceeds those boundaries cannot be ignored, especially when disinformation is expected to sustain the profile of future conflict through global media and social networks.

These conflicts will not feature uniforms and flags, and the cyber domain will make it possible to force a new perception. The marriage between hybrid warfare and disinformation and its impact on our critical advantage, Air Power, may generate new social environments that will demand a more effective defence: A stronger defence not only against the visible opponent, but also against the warriors that cannot be seen, against the uncertainty they generate in the population, and in the future, against unleashed machines flying solo.

1. Bettina Renz. 'Russia and Hybrid Warfare'. In Contemporary Politics, 2016, Vol. 22, No. 3, 283–300. Online at http://www.tandfonline.com/doi/full/10.1080/13569775.2016.1201316. Accessed 30 Jan., 2017.
2. Dave Johnson. 'Russia's Approach to Conflict: Implications for NATO's Deterrence and Defence'. In NATO Defence College Forum Paper 24 'NATO's Response to Hybrid Threat', p. 137. Rome, 2015.
3. Guillaume Lasconjarias and Jeffrey A. Larsen. 'Introduction: A new Way of Warfare'. In NATO Defence College Forum Paper 24 'NATO's Response to Hybrid Threat', p. 1–2. Rome, 2015.
4. Heidi Reisinger and Alexander Golts. 'Russia's Hybrid Warfare: Waging War below the Radar of Traditional Collective Defence'. In NATO Defence College Forum Paper 24 'NATO's Response to Hybrid Threat', p. 116–117. Rome, 2015.
5. Aapo Cederberg et al. How can Societies be Defended against Hybrid Threats? Geneva Centre for Security Policy. Sep. 2015. Available at: http://www.gcsp.ch/News-Knowledge/Publications/How-are-Societies-Defended-against-Hybrid-Threats
6. Ibid.
7. R. A. Renner. 'America's asymmetric advantage: The utility of airpower in the new strategic environment'. Defence Studies, Vol IV, 2004. Available at: http://www.tandfonline.com/toc/fdef20/4/1
8. James Corum. 'NATO Airpower and the Strategic Communications Challenge'. In: Journal of the JAPCC, Edition 21, 2015, p. 42–48.
9. Maj Gen Ruben C. Garcia Severt et al. 'NATO Air Policing Against Unmanned Aircraft'. In: JAPCC Journal Edition 23, 2016. p. 90–95.

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was commissioned through the Spanish Air Force Academy as an Officer in 1992. Following operational and instructional postings in several Units, flying mainly the F-18 Hornet, he completed his Command Tour as the 462 SQN Commander in the Canary Islands. After graduating from the Joint Staff College in Madrid, he was posted as an Air-to-Air instructor at the Tactical Leadership Programme. Among other missions, he joined ISAF as the acting Air Liaison Officer, TACP Commander and Airfield Coordinator for the Spanish Battalion. He returned to the Staff College as an Instructor in 2012 and is currently the Manned Air Defence Subject Matter Expert at JAPCC. Lieutenant Colonel Presa holds a Ph.D. in Linguistics.

Lieutenant Colonel Martin Menzel, MBA,
began his military carrier in 1985, spending several years in the German Army Engineer branch including positions as Company Commander, and as Chief Instructor at the German Army NCO School. In 1999, he stepped over into the Military Intelligence branch. With a broad range of intelligence positions and functions held at Headquarters 1st German/Netherlands Corps, Joint Force Command Brunssum. SFOR, and ISAF, he became a highly experienced staff officer with regard to the conduct of military intelligence at the operational level in NATO or multinational staff environments. Since May 2014, Lieutenant Colonel Menzel has been the JAPCC's Subject Matter Expert for Research, Analysis and Intelligence Support as well as serving as Assistant Editor of this journal.

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Active Layered Theatre Ballistic Missile Defence: The NATO Communications and Information Agency (NCIA) is leading an effort to provide the NATO BMD architecture with enhancements to NATO C3 systems.

The Competence Centre for Surface Based Air and Missile Defence

Preserving the EADTF Legacy and Furthering the IAMD Mission

By Lieutenant Colonel Thorsten Tanski, Dipl.-Ing., DEU AF, CC SBAMD

History

On 3 December 1999, the Extended Air Defence Task Force (EADTF) was installed in Burbach, Germany. At that time, the mission spectrum for Ground Based Air Defence (GBAD) forces had expanded to include the defence against Ballistic and Cruise Missiles. The only GBAD weapon system that could deal with this broader threat was the PATRIOT system, so the three user nations became the EADTF founding members.

The EADTF was designed as a small, flexible organization, made up of 34 German, Dutch, and US soldiers. Its original mission was twofold. In peacetime, the Task Force was to enhance planning and coordinating of combined air defence activities, including training, exercises, and interoperability tests. The goal was to satisfy requirements for more interoperability between the nations and to develop common training, tactics, and procedures (TTPs). Additionally, the need emerged to embed the 'new' capability into the NATO

Integrated Air Defence System (NATINADS) and to provide Theatre Missile Defence (TMD) for out-of-area missions. Thus, this new Task Force also received a distinct operational role and was set up to enable or assume mission-related command and control functions for AD/TMD organizations. During Operation DISPLAY DETERRENCE in 2003, US and Dutch EADTF personnel accomplished the first operational assignment by providing guidance and support to enhance NATINADS in the defence of Turkish territory.

Due to major restructuring and base closures within the German Air Force in 2004, and the US withdrawal from the Task Force in 2008, the EADTF eventually moved into the current facilities of NATO Allied Air Command (AIRCOM) headquarters, located at Ramstein Air Base. Reassessing the value of the EADTF, the remaining member nations decided to continue the successful cooperation. Subsequently, the EADTF became one of the flagship examples of intensified bilateral military cooperation between Germany and the Netherlands.

In the following years, the proliferation of ballistic missiles became a major concern for NATO and its member nations. By then, the EADTF was ready to answer the call for providing in-depth operational and technical expertise in this specific area. It supported NATO in developing software prototypes as well as operationalizing the Active Layered Theatre Ballistic Missile Defence (ALTBMD) Interim Capability for planning and executing of the (T)BMD mission.

In its Strategic Concept 2010 and subsequent summit communiqués, NATO reiterated the prioritized commitment to build a substantial, integrated, and interoperable (T)BMD capability. With NATO's decision to build organic, interoperable, and standardized C2 resources and procedures (BMC3I), the EADTF succeeded in its original mission while still supporting the NATO Command Structure in furthering and sustaining this new capability.

CC SBAMD and the EADTF Legacy

Whilst the EADTF had a significant reputation for its operational value and subject matter expertise in (T)BMD, the implementation of Integrated Air and Missile Defence (IAMD) concepts by NATO Allies called for respective high-level expertise and capabilities. Acknowledging this requirement, in December 2012 the German-Dutch General Officers Steering Committee (GOSC) initiated the transformation into the Competence Centre for Surface Based Air and Missile Defence (CC SBAMD). Since then, the new, more generic mission has been to provide premier operational level expertise as well as operational and training capabilities in the field of Surface Based Air and Missile Defence. Today, the CC SBAMD staff is comprised of 18 highly trained and experienced personnel from Germany and the Netherlands, while the Commander and Chief of Staff positions rotate between the two nations. The relevance of a joint approach in contemporary IAMD operations is underscored by voluntary representation of both nation's navies within the Centre.

'The implementation of Integrated Air and Missile Defence concepts by NATO Allies called for respective high-level expertise and capabilities.'

The CC SBAMD is neither part of the NATO Command Structure nor the NATO Integrated Air and Missile Defence System (NATINAMDS). It can, however, support and reinforce existing NATO Headquarters or assist or command a multi-national Task Force. Because of this, the CC SBAMD is a small but crucial element in support of NATO's Smart Defence and the development of the Framework Nation Concept's AMD cluster.

Furthermore, the CCSBAMD is one of the building blocks of German-Dutch military cooperation. It has close ties with the German-Dutch APOLLO project, which promotes SBAMD cooperation at the tactical level, but is not intended to become an elite binational SBAMD think tank. Rather, other nations with respective SBAMD (including (T)BMD) capabilities are invited to contribute in a liaising role or even as a permanent member of the Centre.

CC SBAMD Vision and Policy

For historical reasons, (T)BMD will for now remain the CC SBAMD's main field of expertise within the AMD arena, but the scope is broadening. In the light of the increasing relevance of the threats posed by Cruise Missiles (CM), Anti-Radiation Missiles (ARM), Unmanned Aerial Systems (UAS), and Aircraft, the CC SBAMD will continue to focus on a wider range of issues regarding the integration of Joint and Combined SBAMD capabilities and forces.

Based on current capabilities, threats and near-future trends, the GOSC and the respective staffs are developing the CC SBAMD's annual programme of work with prioritized activities that can be summarized into four categories. These categories are inherently overlapping and interlocking, and consequently, the different activities will have multiple effects as they serve to provide first class advice to all partners and stakeholders while at the same time preserving leading levels of expertise within the organization.

1. Planning and Execution of (T)BMD Missions. The CC SBAMD can provide up to three teams that will be qualified for both (T)BMD planning and mission execution. Based on military requirements, these teams are capable of planning Command and Control (C2) structures, Air & Missile Defence (AMD) sensors, and weapon systems at the operational and tactical level. Furthermore, these teams are also capable of executing operations in NATO's defence against air and missile threats whilst utilizing modern NATO BMC3I systems.

When NATO enhanced its defensive posture for ACTIVE FENCE TURKEY (AF TUR) in 2013, the EADTF not only provided planning expertise for developing the initial defence design and dedicated training for deploying troops, but also provided significant personnel support to sustain HQ AIRCOM's BMD mission. For about one year, up to two crews were permanently assigned to NATO in order to sustain the manning of the BMD Operations Centre. Even today, CC SBAMD personnel are regularly transferred to NATO as a Voluntary National Contribution (VNC) in order to support the BMD mission of the HQ AIRCOM's Ballistic Missile Defence Operations Centre (BMDOC). With this direct support to NATO's peacetime BMD mission, CC SBAMD contributes its special expertise while remaining qualified in the field of the BMD mission execution.

2. Providing AMD Expertise. The EADTF gained a level of expertise and knowledge to support NATO (HQ, SHAPE and HQ AIRCOM) in developing AMD policy and doctrine, concepts, plans, and other AMD-related documentation. The CC SBAMD will conserve the expertise and continue to stand by to give substantial advice to the NATO Command Structure if required. Although currently only bi-nationally sourced, the Competence Centre supports NATO in the development of IAMD capabilities and C2 systems (e.g. ACCS and AIRC2IS) from an operational user perspective. The same expertise also enables the CC SBAMD to contribute to the respective national Air and Missile Defence decision-making processes. Working closely with both the national decision-making and NATO entities at all relevant levels will ensure the Competence Centre maintains a high level of expertise. To this respect, close cooperation will continue to have mutual benefits for all stakeholders in the field of SBAMD.

3. Education and Training of AMD Personnel. It is in the interest of the Competence Centre to promote the subject of SBAMD to a wider audience to create more visibility and awareness. Thus, it is of utmost relevance to create opportunities for vivid discussions and education in the field of IAMD. The CC SBAMD approach to cater to this requirement is twofold.

First, it hosts the internationally renowned 'Air and Missile Defence Conference' that is unique in its particular focus. While covering current trends and issues in the field of IAMD at the operational and strategic level, its target audience deliberately includes the tactical operator (down to unit level) to spur mutual understanding and exchange. Second, the CC SBAMD programme of work includes the provision of dedicated training opportunities within its very expertise domain – at no cost. There are two venues available. The CC SBAMD 'Advanced Air and Missile Defence Course' is a semi-annually hosted, one-week, in-house event to provide education in the field of NATO Integrated Air and Missile Defence to functional area personnel from (multi)national HQs. Further, the Competence Centre provides 1–2 day 'Focus Seminars' at NATO and member nations' entities tailored to their special requirements, including senior leadership training.

4. Multinational Cooperation. The former EADTF and the current CC SBAMD have gained experience and expertise in multi-national cooperation through a number of NATO-centric and multi-national exercises (Nimble Titan, Joint Project Optic Windmill/Joint Project Optic Alliance) as well as during more delicate projects e.g. within the framework of the NATO – Russia Council. This level of involvement qualifies the CC SBAMD to assume prominent roles in co-operative efforts, including its assistance to the NATO Air and Missile Defence Committee as well as the Panel on Air and Missile Defence. Further, reaching out to science and research entities, including contacts to national armament research as well as NATO agencies and other competence centres (e.g. JAPCC), provides insight into future trends in the IAMD domain. In that capacity, the CC SBAMD contributes to the development of future NATO BMC3I systems.

Summary

The CC SBAMD is a relatively small entity, but tailored, organized, and equipped to render a unique capability for Germany and The Netherlands as well as NATO and international partners. It continues to accomplish its mission by connecting to the network of external

A German PATRIOT missile launcher deployed outside Karamanmaras (Turkey).

Deploying a PATRIOT missile defence system.

expertise, using long standing liaison connections, and linking to science and research. Today, the CC SBAMD maintains an immense knowledge repository for the benefit of its member nations, the NATO Alliance, the EU and other international entities.

The knowledge and expertise of the Competence Centre will contribute further to emerging European AMD capabilities, and will have a significant benefit for all participating nations and stakeholders. The CC SBAMD will maintain the EADTF legacy and capabilities in the fields of operations, concept development, experimentation, intelligence, coordination, and education and training. The small personnel footprint, however, mandates the efficient use of resources. By putting a smart focus on current topics and future trends in the field of Air and Missile Defence, the CC SBAMD will remain the prime partner for Surface Based Air and Missile Defence at the tactical, operational, strategic, and policy level.

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joined the German Federal Armed Forces in 1992. He is a ground-based air defence officer and served as tactical control officer, tactical director, S3, squadron commander, and deputy SAM group commander. He was assigned to NATO as Missile Defence and AirC2 expert and deployed to HQ ISAF as planner for synchronization of civil-military operations. Currently, he is serving as the Section Head for Operations and Exercises at the Competence Centre for Surface Based Air and Missile Defence. The author holds a degree in mechanical engineering from the University of the German Federal Armed Forces in Hamburg. He further graduated from US Air Force Command and Staff College as well as the School of Advanced Air and Space Studies.

Mitigating Disinformation Campaigns Against Air Power

A Recent JAPCC Study on Air Power and Disinformation

One of NATO's most stark asymmetric advantages over its adversaries has been the overwhelming strength and flexibility offered by the use of Joint Air Power. Stemming from the air campaign in the Balkans, to operations in Afghanistan and more recently over Libya, not only has the Alliance achieved Air Superiority at the onset of the operation, but maintained control of the skies with limited opposition. This permitted the application of air power to be devoted solely to the delivery of kinetic effect. Our adversaries have recently begun turning our strength against us, and in many ways seeking to reduce the effectiveness of Joint Air Power. The most notable tactic which NATO's non-state and nation state adversaries have endorsed is to seek to impact the political will directing the use of air power through a systematic campaign of disinformation, misdirection and in many cases, misrepresentation of the truth. The JAPCC undertook a study to offer potential solutions to mitigate the effects of this information campaign against the use of air power.

The information domain is becoming a contested environment. This study reviews the historical use of air power throughout the recent history of the Alliance and highlights the rise of opposition information warfare specifically targeting NATO Air Power. Although not a direct adversary of NATO, Russia has taken the position of opposing much of the Western world's use of air power and in a broader sense, opposing, through the use of misinformation, all of the instruments of national power wielded by the Alliance. The study also explores a national perspective of individual Alliance members who represent the majority of NATO's air forces (France, Germany, Italy, the United Kingdom and the United States) to capture the dynamics and impact of national public opinion on the use of air power and how that translates to maintaining (or not) an effective strategic communication campaign. Interestingly enough, these studies reveal similarities but also notable differences between these five nations with regard to the susceptibility and vulnerability to information campaigns. Topics such as the use of remotely piloted vehicles, precision weapons and civilian casualties are reviewed as part of this process.

The Study concludes that the success of adversary disinformation is – among other factors – dependent on the Alliance's representation of air power and its effects to the public. This impacts NATO's ability to conduct their own information operations and in many cases, translates to a measurable impact on the rules of engagement governing the use of air power. The JAPCC further concludes that the threat posed by enemy disinformation operations can be addressed and overcome through a properly tuned strategic communications organization, doctrine, education, resources and – last but not least – simple, clear and unique strategic communications themes presented to the public. This includes not only properly educating the public on the positive aspects of air power, but also correctly bounding and addressing its limitations.

This JAPCC study is meant to function as one of the first steps on the road to successfully combatting misinformation and disinformation campaigns that threaten to render one of the Alliance's foremost tools ineffective. A White Paper will be published soon and become available online at: www.japcc.org ●

Inside a cockpit simulator at the LOM PRAHA Flight Training Centre.

Training the DCA/QRA Trainers at the MATC

The Multinational Aviation Training Centre (MATC), which became an official NATO resource in 2016, recently conducted its first Defensive Counter Air/Quick Reaction Alert (DCA/QRA) Training Module with tactical simulation for pilots and Ground-controlled Interception (GCI) controllers. The training audience came from Hungary, Croatia, Slovakia and the Czech Republic (CZE) and gathered at the LOM PRAHA Flight Training Centre in Pardubice, CZE, from 27 February to 3 March, 2017. This group comprised of pilots and controllers who will be responsible for further virtual training within their respective nations.

The LOM PRAHA tactical training simulator is able to generate scenarios covering nearly the full spectrum of air operations, thus providing invaluable training for the users of the eight tactile cockpits and the several integrated GCI posts. The main controller console displays the air picture as well as data from the eight cockpits, including their radar picture, engine and flight parameters and weapons and sensor status. This allows the instructors to have full situational awareness for mission monitoring, tactical direction and debriefing options. The eight cockpits are based on the SAAB Gripen featuring HOTAS (Hands on Throttles and Stick) controls, but the digital displays can be customized to represent several different aircraft currently in use by NATO.

The training profiles of choice for this week were focused on DCA/QRA, including Beyond Visual Range scenarios. In accordance with the Letter of Agreement signed between the MATC and the JAPCC, a JAPCC SME supported this training with academics about Counter Air in general and DCA in particular. The JAPCC SME also acted as mission monitor when required. Our support further included recommendations about potential building blocks, future development of complex virtual scenarios, and interoperability options for the MATC nations through a shared syllabus in order to minimize costs while maximizing training effectiveness.

The overall training results were excellent, as the simulation software is highly realistic and the training audience demonstrated a great level of technical and procedural knowledge, as well as the highest levels of airmanship. Potential future commonalities with other nations and institutions are being explored through the JAPCC Air & Space Power network. JAPCC's initial contacts with the Tactical Leadership Programme (TLP) regarding the MATC initiative may open new options for advanced Composite Air Missions (COMAO) training in such virtual environments.

Army soldiers train fast roping from a Belgian NH-90 helicopter during Exercise 'Black Blade 2016'.

Helicopter Users Data Base

A New JAPCC Project to Improve Capability Building

Helicopter capabilities are probably the most heterogeneous within the Alliance's military aviation inventory. Helicopter units are scattered through all services and, more than in other flying units, they vary significantly in size, organizational structure, and operational capability. At one end of the spectrum there are the highly specialized and trained but equally scarce Combat Search and Rescue (CSAR) and Medical Evacuation (MEDEVAC) units, at times counting only a handful of aircraft. At the other end of the spectrum there are the Attack and Transport helicopter squadrons or battalions counting larger numbers of platforms.

In addition, the obvious hierarchical relationship between provider and customer is quite often sub-optimized leading to less than ideal circumstances in which to improve capability building. This reality poses a serious challenge for planners at all levels responsible for building, maintaining and enhancing national helicopter capabilities. At present there are only few opportunities for helicopter units to train together in a multinational environment where combined force missions are planned and executed in a complex and challenging scenario. In order to realize the potential benefits of standardization efforts in crew training this must change.

In order to improve this capability building, the JAPCC is launching a project to create a tool that provides rotary-wing agencies, staffs and units with overarching situational awareness concerning helicopter-specific exercises and events as well as the respective Points of Contact (POCs). This tool would allow the users to better prioritize and plan their activities, ultimately leading to better understanding, increased interoperability and more efficient allocation of human and financial resources for helicopter capability building.

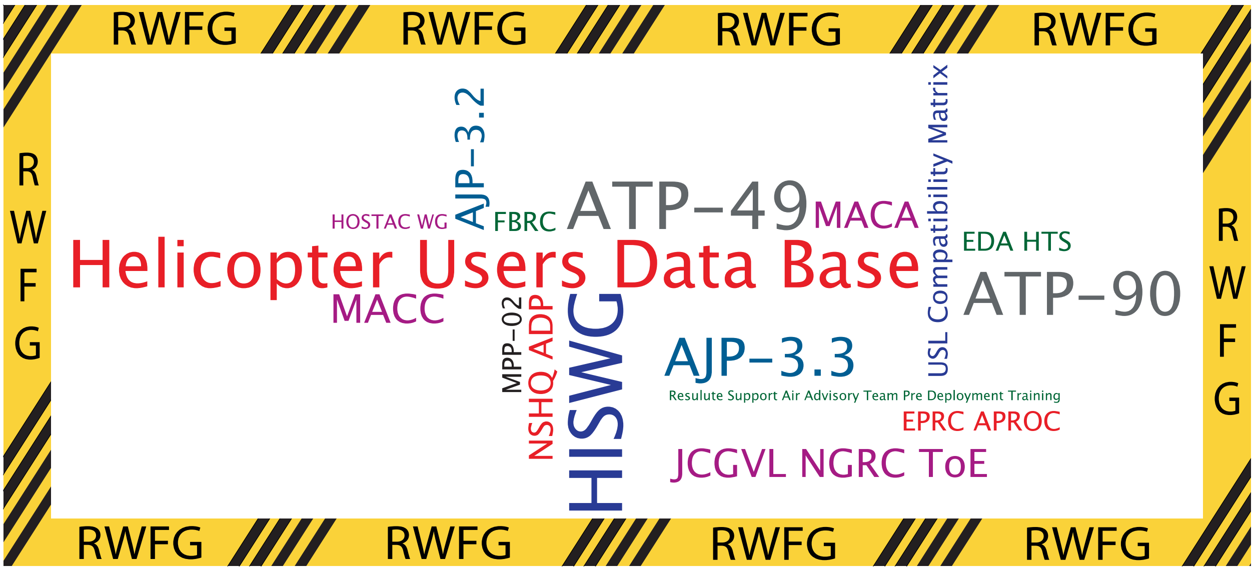
The JAPCC Rotary Wing Focus Group (RWFG)

Rotary wing assets are widely used by all services among the Alliances' militaries and have always represented very critical capabilities in NATO-led operations. In order to best assess the current situation, recommend a way ahead, and monitor progress in the development of these capabilities, the JAPCC has established an internal working body called the Rotary Wing Focus Group (RWFG). The RWFG is to increase awareness and coordination among the assigned Rotary Wing Subject Matter Experts (SMEs) and their branch heads, in order to improve the quality of their work through a well-defined working method.

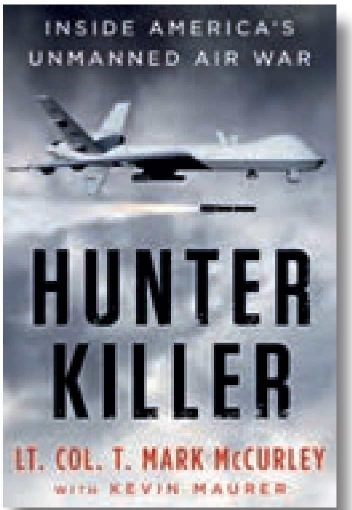
Today the RWFG counts five JAPCC SMEs with varying backgrounds from four different nations. They are spread over the Air Operation Support and Combat Air branches within the JAPCC. The RWFG also reaches out to other experts, either within the JAPCC or in Allied Air Command, Combined Air Operations Command Uedem or the German Air Operations Command Kalkar in order to support the development of specific projects or the organization of specific events. Due to the inherent process of consensus making, this working method significantly increases JAPCC credibility within the larger community of helicopter users.

Much as in the JAPCC itself, the projects and objectives managed by the RWFG range from the very tangible to the very conceptual. Examples of the former are the contribution to the development of ATP-49 'Use of Helicopters in Land Operations' and ATP-90 'Operational Competencies for Helicopter Crews in Support of NATO-led Land Operations and Exercises' within the Helicopter Inter Service Working Group (HISWG) and of a Helicopter Under-Slung Load compatibility matrix. Examples of the latter are the development of a white paper on the 'Future Battlefield Rotorcraft Capability' in parallel to the contribution to the NATO Army Armament Group/Joint Capability Group Vertical Lift/Next Generation Rotorcraft Capability Team of Experts of which the JAPCC has vice-chairmanship. ●

The JAPCC RWFG may be contacted via the functional group email box RWFG@japcc.org.



'Hunter Killer – Inside America's Unmanned Air War'



By Lt Col (ret.) T. Mark McCurley,
with Kevin Maurer,
Dutton, 2015
Reviewed by:
Lt Col Pål Kristensen, NOR AF, JAPCC

In *Hunter Killer,* US Air Force Lieutenant Colonel (ret.) T. Mark McCurley provides us his memoirs about the rise and use of Remotely Piloted Aircraft (RPA) within the US Air Force. He piloted the MQ-1 Predator as well as the MQ-9 Reaper reaching more than 1,000 flight hours. Prior to his retirement, he commanded the 60th Expeditionary Reconnaissance Squadron in Djibouti.

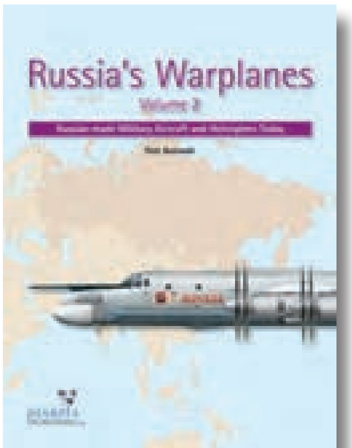
McCurley's memoirs let the reader get into his mind as he and others develop innovative ways of utilising the Predator during the different types of RPA missions. He takes the reader into the operations room as RPA are employed for the first time against seaborne threats. He lets us experience the difficulties in setting up a Deployed Operating Base for the RPA in Djibouti and the stress on RPA personnel and equipment caused by continuous operations under harsh conditions. The book culminates with the author's report on the final phase of the tactical mission that resulted in the killing of Anwar al-Awlaki, one of the world's most wanted terrorists.

The easy-to-read book provides an unprecedented personal insight into an RPA pilot's career through education and training to the actual mission. It furthermore covers McCurley's experience as a squadron commander and the struggle to stay operational during critical phases of operations, including losses of several airframes. Readers with no or limited knowledge on RPA will learn a great deal about the capability of this still fairly new tool on the battlefield. ●

'Russia's Warplanes: Russian-made Military Aircraft and Helicopters Today (Volume 2)'

Ongoing worldwide geopolitical developments such Russia's intervention in Syria are nurturing western analysts' interest in Russia's current and future military capabilities. Though Russia's economy is affected by sanctions following the Crimea invasion that could hamper ambitious military modernization programs, Russia appears to be back on the scene with most advanced military capabilities. The book *Russia's Warplanes* therefore seems to be arriving at just the right time. While Volume 2 is dedicated to long-range bombers, maritime patrol and anti-submarine aircraft, strategic airlift and trainers, it also includes an update on Volume 1, which detailed tactical combat aircraft, attack and transport helicopters, reconnaissance and surveillance aircraft, and special mission aircraft including airborne command posts and relay aircraft.

Altogether both volumes represent an excellent compendium and reference. Not only will the reader find detailed, accurate technical descriptions of each military aircraft, but also historical background and a projection on upgrades and future technology developments such as avionics and advance weapons. Already announced is an additional Volume to follow-up on air-launched weapons and carrier aviation in order to complete the overview of Russian air power means and capabilities. Again this book is most valuable for anyone interested in Russian military aviation. ●



By Piotr Butowski
Houston, TX,
Harpia Publishing L.L.C., 2016
Reviewed by:
Lt Col Ralf Korus, DEU A, JAPCC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