Transforming Joint Air and Space Power

The Journal of the JAPCC

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After three exciting years in Kalkar, my tour as the Assistant Director of the JAPCC and the editor of this Journal ends in September 2021. The time consuming task of being the editor of this Journal was well rewarded by the educational, innovating and thought-provoking articles we published in the past few years. I want to thank our authors for sharing their knowledge and experience, and our loyal readers, for their continuous interest and their constructive feedback.

I am excited to present to you Issue 32 of the JAPCC Journal of Air and Space Power, which starts with an article by our Executive Director, Lieutenant General Klaus Habersetzer. In his final Journal contribution as the Executive Director, he highlights a number of important dynamic challenges in response to which NATO needs to adapt both its operational capabilities and decision-making processes.

The next two articles provide us with senior Leadership Perspectives on 'The "Land Approach" to the Space Domain' by Major General Gianluca Carai and Brigadier General Sławomir Żakowski's insights regarding the 'Polish Air Force – Transition from Warsaw Pact to NATO'.

The Transformation & Capabilities section follows and includes two Space articles. 'Responsive Space for NATO Operations Part 2' continues on from its first iteration in Journal 31 and it will be concluded with a final article in Journal 33. 'Space Tribes' explains the composition of the crowded space community and their differing interests. Articles then shift focus towards the Air Domain. 'Hypersonic Weapons' and 'Air Power: The 6th Generation of Aircraft' discusses defining Air Power challenges of our time, while 'Leveraging the Alliance's Effort in Fighter Aircraft Design' provides insights into the facilitation of multinational research and technology development. 'Transitioning NATO to an All-Domain Mindset' describes the NATO JADO way ahead and how to overcome the obstacles between services and across the nations. The article 'Big Data in ISR' takes a look at the exponentially increasing data and information available and how processing it will be the key to achieving effective results. Rounding out this section 'The Multinational Multi-Role Tanker Transport Fleet Programme' provides an overview of their programme and critically examines its relevance for NATO-EU military air mobility.

The Journal moves on to a View Point on 'Bots Taking Over', elaborating on the role of AI in a new era of decision-making and last but not least, our colleagues from the NATO MILMED CoE provide an insightful look into the current procedures for 'Aeromedical Evacuation in NATO' and give an outlook on the challenges they have ahead.

Thank you for taking the time to read this edition of our Journal. I hope you find this offering as informative and stimulating as I did. We at the JAPCC greatly appreciate any feedback and thoughts you may wish to share. I encourage you to reach out to us via our website at www.japcc.org, like us on LinkedIn, Facebook or Twitter, or send us an email to contact@japcc.org to give us your opinion.

Ciao and good reading!

Giuseppe Sgamba
Brigadier General, IT AF
Assistant 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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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.

Dynamic Challenges and the Need to Adapt

Looking Ahead for the Improvement and Transformation of Joint Air and Space Power

By Lieutenant General Klaus Habersetzer, Executive Director, JAPCC

Since its establishment in 2005, the Joint Air Power Competence Centre (JAPCC) has aimed to provide key decision makers with effective solutions to Air and Space Power challenges. This is our mission, and by doing so, we contribute to the safeguarding of NATO and our nations' interests. Throughout the last 16 years, the JAPCC has been an extremely active 'think tank' for Air and Space Power. As an operational-minded Centre of Excellence (CoE) for NATO, the JAPCC has supported the development of concepts, the drafting of doctrines, as well as training, exercises, and other efforts to enhance the operational effectiveness of our combined and joint forces.[1]

Admittedly, the prevailing pandemic situation did not leave the JAPCC untouched. However, our personnel quickly adapted to the new working conditions, changed their daily routines while continuing to pursue their activities, completing existing while also initiating new high-priority projects. The JAPCC continued to answer Requests for Support from NATO and allied nations, maintain exercise support and issue well-received publications. The White Paper on Resiliency in Space, and a comprehensive handbook covering the diverse aspects of countering the full spectrum of unmanned aircraft and their system components are just two examples. Additionally, with 'NATO Joint All-Domain Operations (JADO)', we launched a multi-year comprehensive project that is structured to address various challenges related to the requirements for operating in a multinational all-domain environment.[2]

A Dynamically Developing Security Environment

The management of emerging conflicts is supposed to be a political and diplomatic endeavour. However, various actors continue to use the military as a primary means to deal with political conflict, as we have seen in areas like Eastern Ukraine, Syria, Libya as well as Nagorno-Karabakh. We also perceive an increasing competition between main state actors. Russia continues to threaten its neighbours, disregard international law, and interfere in our societies. The rise of China has seen an increased economic surge and various approaches to shape the global exchange of goods and services, and the rules governing the world economy in their favour. For many years, China has invested considerably in military and technological capabilities that enable the use of hard power. At the same time, they developed capacities and tools for orchestrated influence campaigns.

We are constantly subject to both open and disguised attacks on the cohesion of our Alliance and on that of our partners with whom we share common values. Cyber-attacks occur daily, and hybrid activities and the potential denial of access to areas and domains are all part of today's security challenges. New categories of weapons employing advanced technologies, including a huge variety of unmanned systems, anti-satellite weapons and hypersonic vehicles, all add new demands to the way we organize our defence.[3] This is a challenge to NATO and its member nations. Additionally, it is a demand on us, the military and civilian Air and Space Power experts, to support adjusting processes and structures, and promote the development of the capabilities to provide a credible force that will achieve success in current and future conflict environments.

Consensus-Building and Decision-Making

NATO has acknowledged this dynamic security environment and the need to adapt. Allied Defence Ministers agreed in February 2018 to establish two new commands: Joint Force Command Norfolk, US covering the vast geographic areas from the US East Coast, past the Greenland-Iceland-UK gap into the Arctic, and the Joint Support Enabling Command in Ulm, Germany to ensure seamless, swift, and secure movements of NATO forces through SACEUR's Rear Area in Europe.

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Additionally, the Alliance Chiefs of Defence (CHODs) agreed to NATO's Military Strategy in May 2019 and directed the implementation through two capstone concepts. The Concept for Deterrence and Defence of the Euro-Atlantic area (DDA) provides a framework for the employment of the Alliance's Military Instrument of Power (MIoP) to deter and defend against known threats, whereas the NATO Warfighting Capstone Concept (NWCC) sets a 20-year vision to develop the MIoP.

It is understood as well that the Alliance will have to support rapid consensus-building and decision-making. This has been particularly recognized in supporting the political process of consultation and coordination between allies and includes deliberations to strengthen pre-agreed authorities within NATO.[4] NATO commanders at a higher level will need the authority to initiate planning and increase readiness to enable appropriate and quick responses.

A political decision at the NATO Summit 2021 to draft a new Strategic Concept could be a starting point to further bolster authorities within the NATO structure at appropriate levels. A strengthened process in decision-making and taking necessary action should be complemented by a discussion on harmonized provisions of technologically enhanced capabilities while ensuring that we are able to integrate crucial existing

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legacy systems. This will contribute to making use of NATO's limited resources synergistically, efficiently, and effectively and will signal NATO is equipped, trained and ready to act at speed.

Leveraging Emerging Technologies

Nearly two years ago, NATO Secretary General Jens Stoltenberg outlined in a speech to the members of NATO's Parliamentary Assembly that 'our security depends on our ability to understand and adopt emerging technologies.'[5] Indeed, Emerging and Disruptive Technologies (EDTs) 'will play an increasing role in the security environment'[6], and operating in a demanding high-end threat environment will require capabilities that can make the best use of them. Automation, artificial intelligence, human enhancement, quantum and cloud technologies and others will have to be leveraged to support our forces when the speed of action and reaction is vital.

Defence innovation, balanced and coordinated, in our Alliance will be a decisive factor in achieving combined success. The NATO 2030 Reflection Group offered convincing arguments and recommendations, pointing out that the Alliance '… has an appropriate and as-yet underdeveloped role to play in providing a forum for discussion on all aspects of EDTs that have a direct bearing on the security of the Euro-Atlantic area'. And, moreover, that 'NATO should serve as a crucial coordinating institution for information sharing and collaboration between Allies on the security dimensions of EDTs', should 'anchor EDTs in the NATO Defence Planning Process (NDPP)', and 'should encourage the incorporation of AI into strategic and operational planning …'[7]

The JAPCC was prepared to initiate a discussion on the best ways to leverage emerging technologies for NATO Air and Space Power at our conference last year. The pandemic situation prevented such a discussion in a traditional conference setting, but we will seize the chance to incorporate this topic into our 2021 conference this September, as an underlying theme as well as a panel topic in the context of 'Delivering NATO Air and Space Power at the Speed of Relevance'. Should you not yet have had the chance, I recommend looking into the Read Ahead that was prepared to serve as an introduction to the Joint Air and Space Power Conference 2020.[8]

Command and Control in Support of Joint All-Domain Operations

In the mid-1990s, 'Network-Centric Warfare' as a concept to achieve 'full-spectrum dominance' provided a vision for interconnected military forces that would achieve success based on enhanced situational awareness at all levels. At the time of its publication, the rapid advancements in IT and cyber technologies had already been perceived, but still offered quite a visionary perspective. Today, the means to provide highly connected entities and systems are available, and further enhanced capabilities that create opportunities for a synergy of effects across traditional domains are in reach. It allows us to link the existing service-related capabilities in a way never imagined before and to adjust our Command and Control (C2) structures and processes accordingly. And it requires us to do so, because our competitors are continually exploiting new methods available through technology to seek a strategic advantage.

To operate across domains requires approaches to planning, C2 and execution of operations that allow rapid decisions and swift subsequent activities without delay. NATO therefore needs to consider how current C2 architectures and processes will have to evolve. Particular points that should be taken into account include providing authority to the right level of leadership and assessing whether supporting/supported relationships are still an effective tool when NATO has to provide C2 at speed. Synchronized and resilient C2, able to support rapid decision-making, is a necessary precondition to increase the survivability of our joint forces in the battlespace and enable the dynamic employment of capabilities that can present adversaries with an overwhelming set of simultaneous dilemmas.

The JAPCC's NATO JADO project is dealing with the important topic of how to organize our C2 for operations across domains and to identify and propose solutions to fully utilize the collective joint and combined capabilities of assets assigned to a NATO-led effort. The project will look into the operational planning process and assess how contributions can be made and where practices should be adjusted. Further aspects of research and assessment will make this project even more comprehensive. As an example, the JAPCC team is collaborating on topics of intelligence and situational awareness and how next-generation collection systems, with resilient large bandwidth data links, can process and disseminate huge amounts of real-time data in the form of actionable decision-making materials. The project is also considering how to best utilize major categories of kinetic and non-kinetic effects derived from a wider arsenal of all-domain capability advances for the Joint Force Commander, how to improve the targeting process in a NATO JADO environment, as well as the broad topic of leadership, education and training for operations in a combined all-domain campaign.[9]

Space as an Operational Domain

Today, the planning and execution of military operations rely significantly on services offered and distributed by space-based capabilities; these capabilities have become a critical element in everyday operations. Furthermore, future joint all-domain operations will need the assured availability of space systems, their space, ground, user and link segments, and the Data, Products and Services (DPS) they provide. The technologies to be used to operate in, from and through Space are rapidly evolving.

Overall, we see that Space is highly dynamic and acknowledge that NATO's officially recognized fifth operational domain has become and will increasingly develop to be a congested and contested sphere. An increasing number of actors are strengthening their capabilities to achieve military objectives in Space, and we have to expect that agreed norms of benign and responsible behaviour may not be adhered to. Therefore, enhanced awareness of what is happening in Space is crucial. We need to understand those

continue to lead and support Space-related work for NATO while this CoE is being established, and is actively engaged with HQ SACT and and the French host nation's establishment team to facilitate its development. Colleagues from this new CoE will then support NATO by assisting doctrine development, education and training, improving interoperability and identifying lessons learned. The JAPCC will, however, preserve dedicated Space expertize to ensure that Space aspects related to Joint Air Power continue to be incorporated in our work in key areas.

factors that influence and affect operations of our own Space Systems, know how different actors act in Space and use Space capabilities, and develop methods to identify and attribute Counterspace activities. NATO and its member states must maintain access to DPS provided by Space systems – and the Alliance's ability to maintain this persistent access will be an important aspect to deterring aggression.

NATO acknowledges the challenges and potential threats we are facing today. Once the NATO Space Centre at Allied Air Command in Ramstein is established and supported by dedicated Space experts, Space Domain Awareness (SDA) can be increased at all levels. The Space Centre 'will help coordinate allied space activities, support NATO activities and operations, and help protect allied space systems by sharing information about potential threats.'[10] In the medium-to-long term, 'the Space Centre can also offer opportunities for multidimensional integration that can prove to be innovation drivers for the Allied armed forces.'[11]

Being fully aware of the challenges in NATO to staff current and prospective billets in the NATO structure with educated and trained Space personnel, the JAPCC applied in December 2019 to assume an official role as CoE for Space. In January of this year, the Military Committee decided instead to accept an offer from France to establish a CoE dedicated specifically to Space in Toulouse. The JAPCC will

Operating in the Electromagnetic Environment

As the example of Space demonstrates, all domains within our military activities are inextricably linked. Our forces have to operate in and across Air, Land, Sea, Space and Cyberspace. Capable adversaries will continue to exploit the possibilities offered to them to interfere. Electronic Warfare (EW) offers relatively low-cost tools and capabilities that may considerably hinder operations of our modern highly linked platforms by denying the use of the Electromagnetic Spectrum (EMS).

Ensuring the use of the EMS was a crucial capability for NATO forces at the height of the Cold War. During many of our crisis management operations, the use of the 'new domains' and the EMS was nearly uncontested. The capable opponents of today, including peer and near-peer competitors, will try to deny this uninterrupted use. In a situation of collective defence, NATO will have to counter comprehensive and orchestrated EW efforts to succeed.

It will therefore be crucial to maintain our ability to use and exploit the EMS and to counter those who would try to deny our freedom to operate. At a highly increased level of quality, the successful fight for control of the Electromagnetic Environment is an indispensable enabler for NATO forces. Means may be explored to circumvent the use of the EMS, however, our ability to employ defensive and offensive EW across the EMS will be indispensable. Maintaining access to this heavily contested environment and the freedom to operate in it will be crucial to support the timely and survivable employment of joint forces and maintain the capability to achieve military objectives.

The Speed of Relevance

NATO Joint Air and Space Power will have to be delivered at the speed of relevance. We need to ensure that strategic decisions continue to enable the application of cutting-edge capabilities and embrace new and emerging technology for their realization. Additionally, our structures and processes need to allow C2 for operations across all domains. The particular opportunities and challenges of the Space domain and operations in the Electromagnetic Environment must be understood, and our concepts and doctrines will have to lay the foundation for operational approaches in an all-domain environment to maintain the necessary level of operational superiority.

Indeed, NATO's defence task has become particularly challenging. Deterrence and Defence will need to take into account the new security environment, shaped by increased state competition, dynamic and disruptive technological development, and the multitude and diversity of potential threats.

As I prepare to relinquish the role of Executive Director of the JAPCC in the near future, I would like to take this opportunity to thank you all for your continued interest and the robust exchange of thoughts and ideas which is so important for our work. Please continue offering your intellectual contributions to the development of NATO Air and Space Power. How we can best ensure that NATO Air and Space Power is delivered at the speed of relevance is going to be discussed at the Joint Air and Space Power Conference 2021. I sincerely hope to see you in Essen, and I look forward to a frank and straightforward exchange of perceptions, thoughts and ideas.

1. For a comprehensive overview of selected products, activities and achievements of the first 15 years, please refer to the JAPCC flyer 'Surface to Exosphere – The Joint Air Power Competence Centre's Impact on Transformation 2005–2020', available online at https://www.japcc.org/portfolio/surface-to-exosphere-the-joint-air-power-competence-centres-impact-on-transformation-2005-2020/.
2. Recent publications of the JAPCC can be found at https://www.japcc.org/publications/.
3. German Ministry of Defence, Reflections on the Bundeswehr of the Future, 9 Feb. 2021.
4. NATO Secretary General, NATO 2030 – A transatlantic Agenda for the Future, 11 Feb. 2021.
5. NATO Secretary General, Speech at the NATO Parliamentary Assembly Plenary Session, 14 Oct. 2019.
6. NATO 2030, United for a New Era, Analysis and Recommendations of the Reflection Group Appointed by the NATO Secretary General, 25 Nov. 2020, p. 19.
7. Ibid., p. 29 f.
8. The Read Ahead is available online at https://www.japcc.org/portfolio/joint-air-space-power-conference-2020-read-ahead/.
9. NATO JADO, A Comprehensive Approach to Joint All-Domain Operations in a Combined Environment, JAPCC Leaflet Feb. 2021, available online at https://www.japcc.org/portfolio/nato-joint-all-domain-operations/.
10. HQ AIRCOM, We coordinate NATO Space Matters, online at https://ac.nato.int/missions/we-coordinate-nato-space-matters.
11. NATO Parliamentary Assembly, Science and Technology Committee, Preliminary Draft Special Report, Space and Security – NATO's role, 2 Mar. 2021, p. 11, available online at https://www.nato-pa.int/download-file?filename=/sites/default/files/2021-04/025%20STC%2021%20E%20-%20SPACE%20AND%20SECURITY%20-%20BRUNNER_2.pdf.

Lieutenant General Klaus Habersetzer

joined the Air Force in 1977. After obtaining his officer's certificate and his diploma in aerospace engineering he was trained as a Ground Based Defender on the HAWK weapon system. He went through various assignments with Air Defence units before participating in the General Command Staff Course in 1990.

He served as Deputy DCOS Stability and Director, Civil-Military Synchronization at the ISAF Headquarters in Kabul, Afghanistan. Afterwards he was appointed Deputy Commander and Chief of Staff, Response Forces Operations Command in Ulm, Germany, before he took over the duties of Chief of Staff, Multinationales Kommando Operative Führung/Multinational Joint Headquarters Ulm.

He took over command of German Air Operations Command in Kalkar and the Combined Air Operations Centre Uedem in September 2018. At the same time he also took over the duties of the Executive Director of the NATO Joint Air Power Competence Centre.

Italian soldiers making use of a Blue Force Tracking system to locate friendly military forces.

The 'Land Approach' to the Space Domain

Developing Space Expertise in Land Forces

By Major General Gianluca Carai, Chief of General Planning and Financial Division of Italian Army General Staff

Introduction

Space has recently been recognized by NATO[1] as the fifth operational domain for military operations and guarantees fundamental services and applications for all Armed Forces, strongly influencing the success of modern military operations.

Main services provided by space platforms include satellite communications, Positioning, Navigation and Timing (PNT) systems, earth observation and Intelligence, Surveillance and Reconnaissance (ISR) applications, all of which ensure essential operational capabilities for Armed Forces. Even services that enable modern equipment, weapon systems and the planning of operations, represent an element of extreme vulnerability, whose temporary or permanent unavailability can lead to trans-versal repercussions across the entire spectrum of military actions.

As stated, space is now considered a physical domain on a par with sea, land, air and cyberspace but, unlike the first three, it is not heavily populated and, relatively speaking, not even trafficked. Therefore, it has previously been treated mostly as a mission, rather than a domain to occupy and protect. However, the situation is rapidly evolving.

The battlefield has been extended vertically and space is an integral part, since almost every soldier has space-enabled devices among his equipment. Currently, the Army uses space capabilities mostly to communicate, navigate, target the enemy and protect its forces. In the near future, it is probable that the Army will become even more dependent on space-based capabilities.

It is therefore evident that tomorrow's soldiers will rely on the expanded use of space capabilities and these features will be essential for enabling all military activity.[2] Furthermore, the integration of space data will enhance the ability to achieve information superiority and full battlespace awareness for full-spectrum dominance.

There will soon be a time when conventional warfare also occurs in the space and cyberspace domains. The Army would be negligent not to develop expertise to help manage these future conflicts and help control the outcomes. The topic of Multi-Domain Operations (MDO), which refers to the inclusion of the cyberspace and space domains with the conventional land, sea and air domains, has begun to energize the doctrinal discussion with allies producing some initial solutions. The advent of the MDO concept is dramatically changing the way the Army conducts operations and continues to be a subject of extreme interest.

The land component must be able to conduct operations that will see it constantly and simultaneously engaged across all five domains in order to overcome problems imposed by adversaries. Similarly to cyberspace, the space domain should therefore be exploited by all Commanders with a different level of penetration from tactical to operational.

It is essential that the Army is expeditionary and responsive to adequately support operations in multiple domains. Land component officers rely on the ability to rapidly and seamlessly integrate space capabilities into their operations, enabling convergence and cross-domain synergy to create multiple

The Army is looking to incorporate the Electronic Warfare Planning and Management Tool in the military decision-making process. Captain Sacarra Pusey, foreground, an electronic warfare officer hailing from Fort Polk, La., worked with the device in February.

Army cyber research, development adapts as tactical network grows.

dilemmas for an adversary. The Army's ability to employ cross-domain fires provides lethal and non-lethal options for commanders and overcomes enemy attempts at degrading or denying space effects.

Developing New Space Leaders

Within this scenario, the Army's strategic role in space, although significant over recent years, is but a glimpse of where we are going in the near future. We foresee a future where the Army, seamlessly integrated into the joint force, will exploit this new domain to its full potential.

Even as we rely on space-based products and services to support ongoing combat operations, our strategic challenge now is to leverage space throughout the entire Army's transformation process. Innovation will likely be a decisive factor in the successful development of space-based capabilities and transformation of the Army's approach in this new domain.

In order to succeed in a highly strategic context such as space, we must give impetus to education and training which has to be full spectrum. The time is right to identify professional paths that ensure understanding of the challenges and opportunities that the space domain is putting in front of every single soldier. To take us through that process, we need space-smart leaders, at every level outside the traditional space fields, who know what space-based assets can do for them and how to harness those capabilities to help them achieve their missions.

This is a complex task that will demand that we also identify positions that require knowledge of space systems and demand that we figure out how the Army is going to educate and train those who fill the positions. A one-week course? A 3-month course? What is the right approach? This is not an easy project nor one that will be implemented soon, but it is one we are convinced we need to get right. There is an increasing need to develop the necessary training and capabilities to successfully operate in a space-conditioned environment.

To carry out this ambitious plan, a significant internal organizational change has occurred as the Army's – and MoD's – view of space has evolved. The Italian

ISR effects influencing the planning phase of an Army operation.

Army recently activated a new Space Office within the Army General Staff that will be responsible for developing these concepts according to the systemic approach of DOTMLPFI (Doctrine, Organization, Training, Materiel, Leadership, Personnel, Facilities and Interoperability). It will also make sure that awareness of the space domain's effects will shape the development of each conceptual area by influencing decision-making at every hierarchical level.

The newly established office will address recruiting and develop versatile, adaptive and innovative space professionals. It will also exploit and deliver responsive, tailored and integrated space-enabled capabilities to Army units and individual soldiers which will effectively synchronize combat, materiel, and development efforts. The office will have to advocate for the required space capabilities and shape acquisitions by identifying and pursuing high payoff technologies and solutions within a restrained and more effective acquisition process.

Education and Training as the Starting Point

It can be assumed that the reliance on space capabilities will significantly rise, as the nature of warfare continues to change as it has in recent years. As this occurs, we will see a changing emphasis, new operational concepts, and differing organizational structures that will be needed to meet the changes of the future.[3]

The Army has a legitimate interest in the future of space and space management and also a moral obligation to its war fighters to ensure that space continues to evolve and meet its operational needs. To meet this obligation, the Army must know what it wants to achieve in space, develop the road ahead, and advocate its concepts in every space forum. This will require 'out-of-the-box thinking' and acceptance of new ideas and concepts by the various elements of our space community.[4] The most important aspect to successfully meet the challenges of the future is to have a holistic approach to space throughout the Army.

Space has changed the way military force is applied and created opportunities to redefine the Army's role in developing its uses. Technological advances have enabled the ability to strike, manoeuvre and determine enemy composition and disposition. We can target and measure effects, but more information is not always better intelligence. Analysis and dissemination are currently the areas with the greatest shortfall. Efforts must focus on developing a global information architecture that is able to provide relevant and actionable intelligence to the planner and war fighter in a timely manner. Making the pieces fit within a joint context is an imperative.

To do this, the Army must invest in its training institute, build space play into its simulations and training exercises, and actively participate in joint and NATO space exercises. NATO should continue promoting training sessions and courses focused on the capabilities, limitations and vulnerabilities of space assets including the operational use of space services and products by Nations and NATO.

A comprehensive professional military space education programme has to be incorporated into all Army service school curricula, providing a relevant, fundamental level of space knowledge to officers, non-commissioned officers and soldiers. As a result, soldiers will be increasingly knowledgeable, skilled and confident working with space systems and products. This is essential and will enable a continuous review of the capabilities required to support combatant commanders and their staffs.[5]

Through education and experience, the number of warriors who understand the space domain will grow significantly. The increasing number of space-smart leaders will demand that Army space equities and requirements are presented, tested, and discussed in all forums. The education of young Army officers in the concept of space-enabled warfare will assume increasing importance as commanders must harness the potential of space-based capabilities to impose lethal and non-lethal effects.

Conclusions

The Army is at an important strategic crossroad, and space-smart professionals are vital to forge the way ahead. The Army is currently facing the challenge not to regress into the development of stove-piped capabilities, but to support and participate in all facets of space development to ensure future capabilities are relevant to the needs of war fighters.

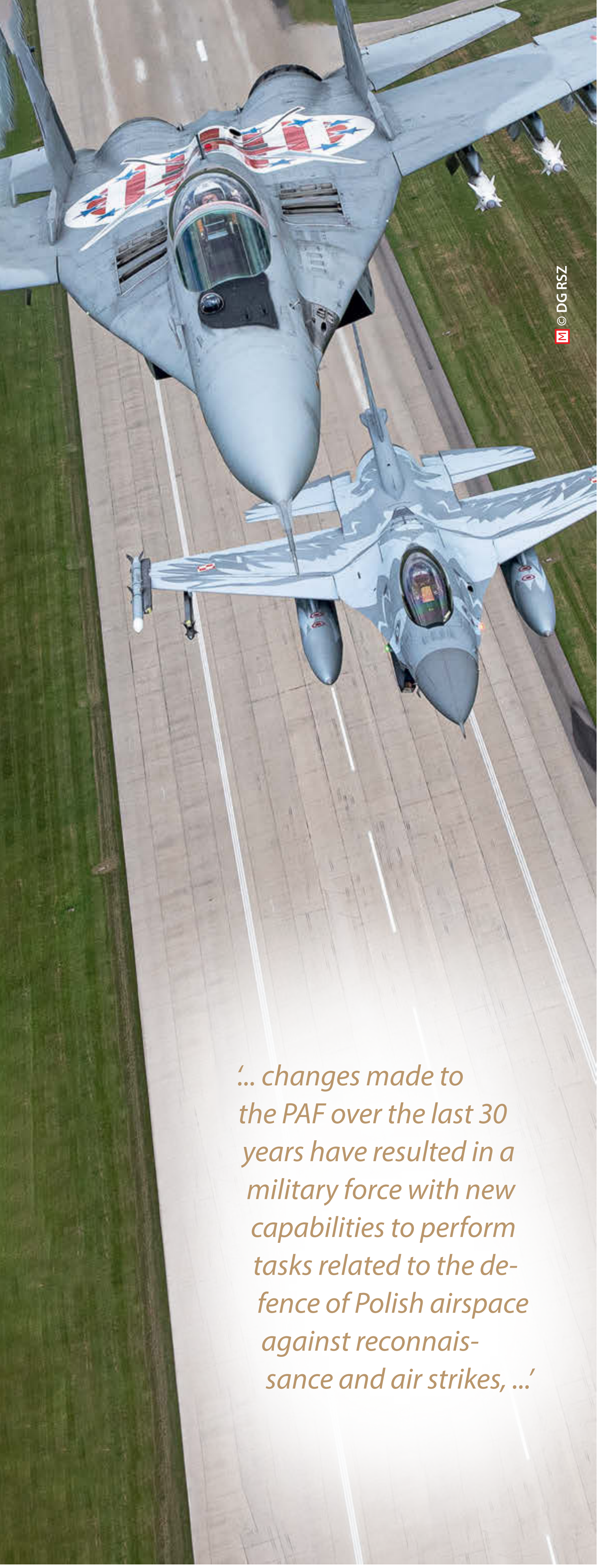
Army concepts and architectures must be integrated and reflect the relevance that the Army brings to the space mission arena. Today, we cannot take space for granted. The western way of warfare has been studied by our potential adversaries, they have observed how we integrate space-based effects into joint operations. They have developed capabilities, doctrine and tactics to restrict our ability to operate in this way, and so they have reduced our advantage.

While continuing to be the main user of space-based services, the Army should stop considering itself as a mere user of space resources and assume a leading role in policy and management of space systems both in national and international contexts. This all starts with solid training and education of its war fighters.

1. NATO, 'NATO's approach to space'. 2020. Online at: https://www.nato.int/cps/en/natohq/topics_175419.htm (accessed 24 Feb. 2021).
2. US Army, 'The US Army in Multi-Domain Operations 2028'. Virginia, US, 2018. United states Army and Doctrine Command: p. 5.
3. Dr Brent, Z, 'The Coming Revolution in Military Space Professionalism', Air & Space Power Journal 32, No. 2 (2018): p. 9.
4. Joint Publication 3-14, 'Space Operations' (10 Apr. 2018): p. 19–22.
5. Lt Gen David, T., Col Gregory, J.G., Mag. Christopher, W. M., 'Space as a War-fighting Domain', Air & Space Power Journal 32, No. 2 (2018): p. 4–7.

Major General Gianluca Carai

started his military education at 'Nunziatella' Military School of Naples (1983–1986). He was commissioned into the 187th Parachute Regiment 'Folgore' aftering completing his studies at Army School of Applied Military Studies of Turin in 1990. During his service, he has commanded the 1st battalion of the 151st Infantry Regiment, the 152nd Infantry Regiment and the 'Sassari' Brigade. He has been deployed to operations in Somalia, Albania, Bosnia, Lebanon and Afghanistan. He has completed several staff appointments at various ranks within the General Planning and Financial Division of Army General Staff, of which he was appointed Chief on March 4th 2019.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Polish Air Force – Transition from Warsaw Pact to NATO

The JAPCC's Interview with Brigadier General Sławomir Żakowski, Deputy Commander, Combined Air Operations Centre (CAOC) Uedem, Germany

By Lieutenant Colonel Zenon Kot, PL AF, JAPCC

'... changes made to the PAF over the last 30 years have resulted in a military force with new capabilities to perform tasks related to the defence of Polish airspace against reconnaissance and air strikes, ...'

Think back to a bygone era, bring back memories and describe what it was like to serve in the Air Force back then.

I associate the 1990s primarily with Poland regaining full sovereignty as a result of the collapse of the Soviet Union and the dissolution of the Warsaw Pact. In 1993, the last Soviet soldier left Polish territory. We were once again able to enjoy freedom, which must be cherished, because nothing is given forever. We remember this well from our history.

Therefore, an intensive search began for a new way to ensure military security. Many concepts were considered at the time, starting with neutrality–following the Swiss model–through to the creation of 'NATO-bis', a concept involving the establishment of

an international military alliance of Central European states which were previously a part of the dissolved Warsaw Pact, and finally accession to NATO. Poland's membership of NATO became our strategic objective in the early 1990s, but our aspirations had to win the approval of our future allies, and it should be stressed that this was met with a reluctant reception by the Russian Federation.

The 1990s were also a period of prolonged economic crisis caused by the collapse of the planned socialist economy, but also a period of successive sacrifices associated with our transition to a market economy. Needless to say, the economic performance of a country has a direct impact on the level of equipment, technical condition and training of its armed forces.

The 1990s saw a significant reduction in our military potential. Obsolete military equipment was withdrawn and the number of garrisons were reduced. The amount of training was also limited.

What was the equipment and what did the training look like?

In the 1990s, the Polish Air Force (PAF) began its transformation to NATO standards. It was a long and bumpy road and we faced many problems and limitations. The basic equipment of those years consisted of Soviet aircraft and equipment. The way the PAF operated was completely different from the Western model, starting from the principles of flight execution, through the concept of technical and logistical support, to the units of measurement used. Financial limitations and subsequent difficulties with the availability of aircraft dramatically reduced the annual flight time of a trained pilot to an average of only 40 hours.

The vision of joining NATO forced changes to our rules, regulations and procedures. New flight training programmes were developed in cooperation with NATO colleagues and it was not only about the syllabus, but also about changing the philosophy of flight training, the way of performing flight tasks, terminology and aviation phraseology.

What were the expectations when Poland joined NATO? In what areas were there the greatest concerns?

Joining NATO opened a new perspective for the development of the PAF. The sense of security and pride has significantly increased in Polish society. Poland became a member of the largest and strongest Alliance in the world, whose 70th anniversary we celebrated two years ago.

Poland's military security system had acquired a new dimension. Security was based on the ability to deter an aggressor in the first phase of a conflict, in order to carry out further defensive operations together with allied reinforcement forces, in accordance with Article 5 of the North Atlantic Treaty. It becomes crucial to maintain air superiority over the area of Poland in order to create and maintain conditions for hosting the reinforcing forces. The development and maintenance of an effective national air defence system has acquired a completely new and decisive significance for ensuring Poland's military security. For airmen, it was the announcement of new equipment, but also the acceleration of our training to achieve full interoperability. We increased the intensity of language training, the knowledge of which became a prerequisite for promotion to successive higher military positions and ranks. We began on a large scale sending our soldiers to participate in training, courses, studies in centres and universities of allied countries. This approach generated further challenges, because the more soldiers attending the schools, the fewer of them there were on exercises. Financial constraints were also a significant factor impacting all decisions made during this period.

Another challenge related to standardisation was the adaptation of our military structures, which was also linked to another reduction. Our greatest expectation was to have modern armed forces, in terms of structures, tactics and procedures, but also equipment and logistical security, to be able to perform tasks as a responsible partner in coalition forces.

Our greatest concern was, and probably still is, whether we will be able to rise to all these new challenges and not disappoint our society. At this point, it is worth emphasizing an objective truth that our road to NATO has repeatedly confirmed; it is easier to purchase new equipment and write new procedures than to change our human mentality and habits.

What changes in specialist training, language training and mission participation were most significant?

The PAF became a leader of these changes by introducing NATO standards to the Polish Armed Forces. We adjusted command structures by abolishing the level of air corps and regiments, replaced by air wings, bases and squadrons. The creation of the Air Operations Centre (AOC) and inclusion of Poland into the NATO Integrated Air and Missile Defence System (NATINADS) system was the driving force for fundamental changes. The analogue guidance system was replaced with a digital one, which significantly increased the capabilities of the operational

command of the military aviation. Modern tactical data transmission systems, including Link 11 and Link 16, were introduced, thus bringing about a new quality in the exchange of digital data, images and voice between air, sea and land platforms.

There has been a very dynamic change in training programmes, aviation regulations and procedures. New aviation regulations have introduced aviation phraseology in English in accordance with ICAO and NATO standards. More missions began to be performed in the civil aviation environment, which took over the management of Polish airspace.

We started using the same units of measure that are used in civil aviation and NATO. Kilometres and metres were replaced by miles and feet, in the initial period using conversion tables, because the on-board indicators were still calibrated differently. This is just one example of the additional burden of both flying and ground personnel in the initial period of change. Modernizing or replacing equipment is a long-term and continuous process. Achieving interoperability is a process, not a single event.

Unfortunately, during this period of change, we have not avoided making mistakes. At every stage the limitations of human factors must be considered. Personnel within the PAF found the transition difficult at times, but their overarching commitment to the challenges and the ultimate goal of security within the country and with NATO saw them secure our place within the Alliance.

How has the PAF benefited from equipment changes to meet the NATO standards?

The changes made to the PAF over the last 30 years have resulted in a military force with new capabilities to perform tasks related to the defence of Polish airspace against reconnaissance and air strikes, which is a capability unforeseen before we began the transition. In times of crisis or war we are also prepared to dominate the airspace, support combat operations of other services, and conduct reconnaissance and air transport wherever required. It is clear, however, that Poland cannot afford to have a combat aviation force capable of independently performing all the tasks related to its use in combat and 'non-military' operations.

The first Polish comprehensive aviation modernization programme was the purchase of C-295M medium tactical transport aircraft in 2003. This was at a time when the expeditionary military was a priority in air force development and Poland was very much engaged in combat, stabilization and peace missions. The introduction of the CASA aircraft was an absolutely new level of quality at that time in Polish aviation. It was not only the glass cockpit, but it gave us new possibilities to achieve transport tasks. The C-295M aircraft replaced the worn-out soviet era An-26. I defined this change by 'a factor of two'; twice as far, twice the capacity and twice as cheap.

However, the real revolution in the Polish aviation was in 2006 with the introduction and training of the new aviation elite – the F-16 Fighting Falcon. These multi-role aircraft formed the backbone of the PAF combat aviation and are designed to perform defensive, offensive and reconnaissance tasks. Using AGM-158 JASSM ER cruise missiles, they can attack enemy point targets outside the range of air defence systems at distances up to 1,000 km. The F-16s are the first combat aircraft fully compatible with allied air units, using the same armament, communications systems, tactical data transmission systems and procedures.

Today, we build situational awareness on the basis of on-board systems, but for this you need appropriate knowledge, which when supported by experience, sets the standards of professionalism.

I am convinced that without NATO this would have been impossible.

Does your current position as Deputy Commander CAOC help in promoting the proactive Polish attitude as reaction and response to the provocative and offensive actions of the Russian Air Force?

Poland has delegated responsibility for conducting Air Policing (AP) missions to NATO, which manages the NATINAMDS system and one of the links in this system is CAOC UEDEM. However, each country has its specific limitations caused by the characteristics of the threats we face. Poland, as mentioned above, is a border state of NATO, but is also a member of the European Union and this situation may give rise to threats that do not exist in other regions. In the Polish airspace we observe the violation of our borders by small aircraft, such as drones, paragliders and ultralight planes regularly. In the vast majority of cases, this is related to criminal activity and in order to counteract this, Poland deploys additional forces and resources as elements of a strengthened national air defence system, which cooperate directly with other institutions and agencies, such as the Border Guard.

I think it is worth considering countering drones especially those flying at low altitude, in light of not only security responsibilities but also having the ability to detect and counter surveillance activities.

My position as Deputy Commander of CAOC UDEM absolutely makes me an ambassador of the PAF in NATO. However, in my everyday activity, I focus on carrying out missions for which CAOC UEDEM is tasked in its AP area of responsibility.

Poland borders the Russian Federation (RF) through the Kaliningrad Oblast, the area which has always been of great military importance due to its location. What consequences and limitations does this bring?

Poland is a NATO frontline state on an easterly direction. It is bordered by the Russian Federation and Belarus, and the alliance of these states is potentially the greatest military threat to NATO and to Poland. The unstable situation in Ukraine poses some additional challenges and certainly does not increase security in the region. In light of Russia's active policy

‘In 1993, the last Soviet soldier left Polish territory. We were once again able to enjoy freedom, which must be cherished, because nothing is given forever.’

as a global player with a wide array of military tools in its arsenal, ranging from sophisticated nuclear forces through conventional forces using increasingly advanced technologies in the land, sea, air, space and cyber domains, to a centralized system for deciding on their use. It is the eastern flank that will be where the direct interests of NATO member states and Russia will clash. In the current geopolitical situation, the narrow Suwałki corridor, a 70 km long strip of land connecting NATO countries with the three Baltic states of Lithuania, Latvia and Estonia, assumes particular importance.

Poland wants to be a credible NATO member and realizes that this credibility depends on having its own national defence capabilities and political will, which translates into ensuring adequate funds for military expenditures.

In 2020, Poland allocated over 2.3 % of its Gross Domestic Product (GDP) to national defence, dedicating a portion of these funds to technical modernization, including the purchase of F-35 aircraft, M-346 Master Advanced Jet Trainer (AJT) aircraft and the IBCS/PATRIOT air defence system.

The PAF actively participates in allied operations, exercises and training. Since 2006, our air contingents have participated in Baltic Air Policing and later Enhanced AP operations. In 2021, a contingent of Polish F-16s will for the first time support an AP operation in Iceland.

I am convinced that Polish pilots are perfectly prepared to carry out tasks in times of peace, crisis or war. A very important element of maintaining high morale is the cultivation of traditions, and for aviators, a special motivation is the reference to the legend of Polish airmen fighting in the Battle of Britain.

Professionalism supported by high morale and full readiness to carry out missions is, in my opinion, the highest value of our contribution to NATO.

Brigadier General Sławomir Żakowski

is the Deputy Commander of Combined Air Operations Centre in Uedem. He graduated as a pilot in 1986 and has accumulated over 3,000 flying hours in TS-11, MiG-15, MiG-21, Su-7, M-28 and C-295M. He has commanded at squadron, base and wing levels throughout the PAF. He served as the Deputy Commander of Polish Air Operations Centre and Air Component Command prior to his current assignment. Furthermore, he is a graduate of the Polish National Defense Academy in Warsaw and the United States Air Force Air War College in Maxwell and as well as the Jagiellonian University in Cracow.

Responsive Space for NATO Operations – Part 2

By Wolfgang Jung, German Aerospace Centre (DLR)
By Lieutenant Colonel Tim Vasen, GE AF, JAPCC
By Dr Dirk Zimper, German Aerospace Centre (DLR)

Introduction

Space Support plays a significant role in today's modern warfare and is a key enabler for NATO's technical and operational advantage. Worldwide technical developments challenge this advantage while Space has become congested and contested.

This is the second article of a series focusing on the Responsive Space topic. The first article was released within JAPCC Journal 31 in December 2020 and focused on definitions as well as international doctrinal concepts. This article is more technically focused and will complement the third and final one, scheduled for release in Journal 33, which will discuss and analyze a potential outcome for NATO.

The first article can be accessed here:

Responsive Space Developments of NATO and Its Member Nations

The aim is to give the reader a short but not too comprehensive overview about recent technological developments. Already addressed in a previous article (JAPCC Journal 27)[1] worldwide Responsive Launch capabilities will not be assessed here again. This article can be accessed here:

NATO

NATO does not yet use the term Responsive Space. Due to its multinational approach as an alliance of 30-member nations, research on procedures that can be categorized as Responsive Space are mainly focused on interoperability, whether via governmental Space-based assets or via commercially available services and assets.[2] Interoperability, data sharing and continuous mission support is one of the key principles of NATO.

United States

The US launched a programme called Operationally Responsive Space (ORS), which was based on Responsive Launch Capabilities for launchers as well as satellite solutions. Subsequently, an ORS Office was established in 2018 to coordinate the programme and was renamed to the Space Rapid Capabilities Office (SpRCO).[3] It still coordinates across the whole Department of Defense with several projects focused on combatant commanders' needs such as the development of low cost rapidly usable Space technology to fulfil an array of joint military requirements. The office is also responsible for the development and fielding of such Space technology and makes it available to the NATO war-fighter.

The Pentagon's new Space Development Agency (SDA)[4] will orchestrate the development and fielding of the future National Defense Space Architecture. This will be a single, coherent proliferated space architecture with seven layers:

1. A global, persistent, low-latency data and communication transport layer.

2. Indications, warning, tracking, and targeting of advanced missile threats.

3. 24/7, all-weather constant custody of time-sensitive targets.

4. Low-latency battle management to enable time-sensitive kill chain closure.

5. Space situational awareness and rapid access for deterrence in cislunar volume (the space between the earth and the moon).

6. Alternate Position, Navigation, and Timing (PNT) for GPS-denied environments.

7. Ground systems and launch capabilities to support a responsive and resilient space architecture.

SDA will rely heavily on Defence Advanced Research Projects Agency's (DARPA) Blackjack programme.[5] That programme aims to develop and demonstrate the critical elements for a global high-speed network in Low Earth Orbit (LEO) providing the Department of Defense with a highly connected, resilient, and persistent coverage.

Germany

On behalf of the German Ministry of Defence, the Responsive Space Cluster Competence Center (RSC3) of the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt [DLR]) explores the technological basis for a national Responsive Space Capability and demonstrates key technologies in Space. To do this, RSC3 draws on DLR's decades of experience and systems competence in Aerospace as well as Defence and Security research. The overall aim is to develop flexible and affordable, rapidly available methods and technologies for operational capabilities that enable small military satellites launched into LEO to become operational within a few days on-demand and on call.

A major element will be the involvement of users and industry already in the Research and Development (R&D) process. The RSC3 takes on a coordinating role in Germany aiming to accelerate the technological refresh cycle significantly. For this purpose, it is essential to accomplish ongoing technological demonstrations and to ensure a regular technological transfer of data from research to industry in order to operate the latest state-of-the-art military products in Space. Standardized interfaces allow an easier data exchange in a multi-domain environment towards the improvement of joint operations. Additionally, they lower the entry threshold for Small Medium Enterprises and start-up companies facilitating seamless synergies between military and civil applications.

New technological requirements and possibilities arise from the use of small satellites in swarms, constellations or as single platforms. A modular and open system architecture is a key requirement and needs to be explored, in order to support rapid interchangeability of Commercial-Off-The-Shelf (COTS) satellite platforms and the integration of a diverse array of components that are required to establish plug & play payloads from Space functional areas such as Satellite Communication (SatCom), Intelligence, Surveillance and Reconnaissance (ISR), PNT, etc. Reducing the amount of data through on-board processing, and a high degree of autonomy with the support of AI-based algorithms, are further key elements that need to be investigated and tested (Figure 1). Amongst the mentioned technologies, an agile and robust operation or control of individual small satellites or entire constellations will be essential to enhance the effectiveness of military operations.

Space Capability

Globally available launch sites and multiple launch service providers, which offer either ground-, sea-, or airborne small satellite launchers with Responsive Space Capability, ensure short-term availability, increase the resilience of the launch segment and will benefit on demand quick reaction space operations. Launcher systems with liquid propulsion are not excluded in advance provided they can be refuelled and launched within a few days.

In addition to the aforementioned Space and launch segment, the ground segment completes the holistic approach of a Responsive Space System Architecture.[6] Mobile control centres and optical ground receiving stations, as well as reactive planning tools, optimized transfer orbits and accelerated commissioning procedures are in development.

Consequently, research and development needs to be undertaken in various areas to benefit the future war-fighter.

The requirements and technological demonstration

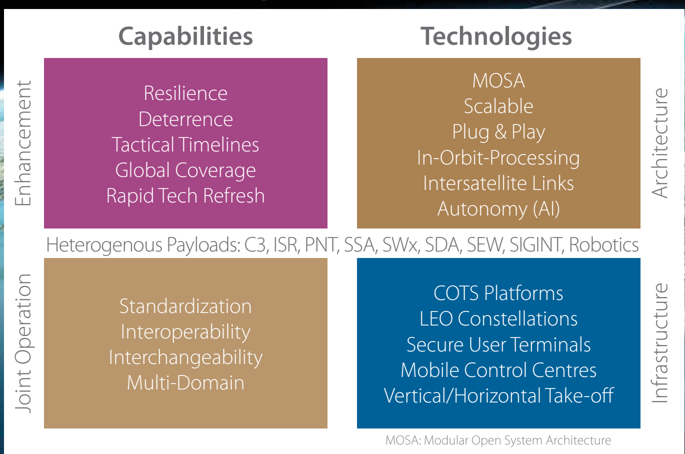

Figure 1: Examples of Key Elements of a Responsive Space Capability.

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missions are currently defined in coordination with the Ministry of Defence, subordinate authorities and in cooperation with the University of the Armed Forces. The RSC3 will demonstrate key technologies as soon as 2021.

Multilateral Approaches

One specific discussion forum, the Responsive Space Capabilities (RSC) Memorandum of Understanding (MOU), needs to be addressed. It is a multinational framework agreement involving the Departments and Ministries of Defence of Australia, Canada, Germany, Italy, Netherlands, New Zealand, Norway, the United Kingdom and the United States.

The overall objective of the RSC MOU is to define and establish the general principles that will apply to the initiation, conduct, and management of Research, Development, Test and Evaluation (RDT&E) cooperation projects detailed in separate Project Arrangements (PAs). Additionally, the MOU allows the exchange of information for harmonizing the participants' military requirements and to assist in defining potential cooperative efforts.

Germany participates in the following three PAs:

1. Responsive Launch and Range (ReLaR) is responsible for exploration, identification, and assessment system concepts for launch and range and technologies reducing launch costs as well as increasing responsive launch capabilities.

2. Micro-Satellite Military Utility (MSMU) is required to explore the military utility of a diverse space architecture including traditional government and commercial satellites, as well as micro- and nano-satellites and their value to an operational theatre.

3. Military Optical Satellite Communications and Optical Space Data Relay (MOSCOM) is responsible for the exploration of the military benefit to free-space optical satellite communications and the standardization of laser-based direct-to-Earth links using a network of interoperable optical ground stations among the partner nations.

Out of the authors' experiences there are additional multilateral discussions in several workshops on responsively usable Space approaches ongoing. The majority of these discussions are exchanges of experiences related to technology standardization and interoperability. The use of future Space architectures such as mega-constellations is also addressed.

Responsive Space Developments Worldwide

Responsive Space is an evolving discipline of military Space support. Most of the ongoing research and development proceeds are restricted. Therefore, it is hard to find and assess information about potential adversaries' capabilities. As a discipline of Space intelligence this information is often classified. To give the reader a slight overview, the projects that are addressed in the following chapter are based on unclassified and well assessed research subjects, but it does not cover all existing projects.

People's Republic of China

In 2015, China established the Strategic Support Force (SSF)[7] which is responsible for all military Space support inside the Peoples Liberation Army (PLA). The SSF is therefore also responsible for the Responsive Space capabilities for the PLA. As of yet, it is not known what stage the establishment is at, but China's Responsive Space is mainly focused on the networking and interaction of already deployed satellites. Due to the enormous number of already launched Chinese ISR satellites, this approach works well in this function.[8] The large number of official civilian, but government-owned offices, agencies, and companies that operate the different satellites on behalf of the government allow this.[9] At least one of the PLA's military universities is researching on how to interconnect existing and future constellations.[10] China has also developed, as a Responsive Launch capability, an inexpensive and mobile launch technology, based on military missile systems allowing replacement of in-orbit degraded systems in the event of an armed conflict.[11]

Russian Federation

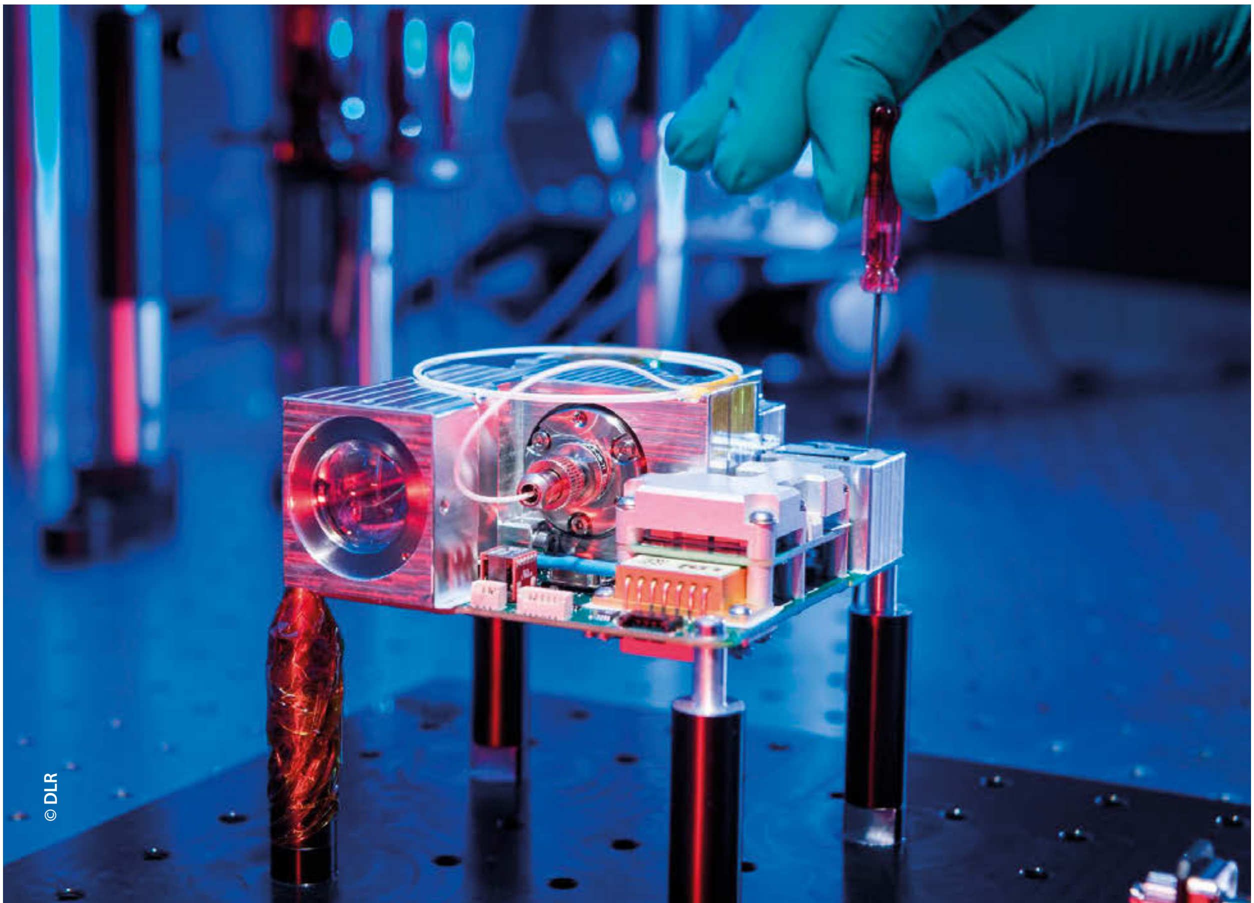
In August 2015, Russia created the Russian Federation Aerospace forces which, at that time, included the Russian Space Forces responsible for Space launches (dual-use, as well as military), satellite operations and operation of the missile defence early warning systems, the satellite control network as well as the Space Object Surveillance and Identification (SOSI) network.[12] Notwithstanding the need for protection of Russia against all kinds or airborne and missile threats, the protection against space threats is also directly addressed.[13]

Planned to be operational in 2028, the 'SPHERA' project, is a complex SatCom Mega-Constellation in LEO.[14] This constellation also integrates payloads from different platforms such as ISR in an interconnected approach. The ISR equipped satellites of 'SPHERA' are codenamed as 'BERKUT'. The constellation will be operated by the Russian Space Agency, ROSCOSMOS, which ensures a military usability, either generally or on request. To ensure a persistent communication service, SPHERA is already projected to integrate platforms other than Space-based systems such as high-altitude airborne platforms or ground-based networks inside Russia. This approach of separating systems into its unique components ensures a high level of robustness.

Interim Assessment and Conclusion

As already stated in the first article, conceptual approaches of Responsive Space are under discussion and in development nearly worldwide. Several approaches in technical developments are being addressed. While the western world is mainly focused on interoperability and standardization, the People's Republic of China, particularly, follows a specific network driven approach. Software solutions to secure network centric support is by their definition the key to responsiveness. Looking into recent commercial Space developments, especially dedicated mega constellations for ISR or SATCOM, seem to be the drivers at least within the next decade. These represent opportunities for militarily usable Responsive Space applications, too.

Further adaptation of national conceptual approaches as well as technical developments for NATO frameworks in standardization and interoperability to support resilient Joint All-Domain Operations (JADO) have to be explored. This includes processes, concepts of operations and technologies[15] to identify solutions for connecting systems across domains and enabling synchronized effects. A deeper analysis on this will be included in the third and final article of this series.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Wolfgang Jung

started as Reserve Officer for Tactical Ballistic Missiles (MGM-52 Lance), followed by two Academic Degrees (Aerospace and Space Systems Engineering). In the last 25 years at DLR's Mobile Rocket Base (MORABA) he was responsible for Launch Services and designing new Hypersonic Flight Vehicles. In 2019 he was nominated as DLR's Coordinator for Responsive Space. At the beginning of this year, he was appointed as the Head of Technology and Department Head for Technology Demonstration at the newly established DLR Responsive Space Cluster Competence Center (RSC3). Besides this, he supports the Air Force Command in Berlin in a Reserve Officer capacity.

Lieutenant Colonel Tim Vasen DipEng, MSc

served for several years in commanding and staff positions within the artillery branch, including a deployment to KFOR as company commander of the DEU ISTAR-company before becoming a career intelligence officer. Serving in positions responsible for IMINT planning and technical assessments, including positions at the office of military studies as a senior analyst for Space systems and head of Space intelligence at the German Space Situational Awareness Centre (GSSAC). Since October 2017 he serves as Space Intelligence SME at the JAPCC, e.g. responsible as OPFOR Space planner in TRJN17, TRJE18, TRJU19 and STJUJA20.

Dr.-Ing. Dirk Zimper

joined the German Air Force in 2004 and holds a doctoral degree in Aerospace Engineering. Professionally trained as an ammunition specialist, he commanded a specialized maintenance unit for aerial missile systems. From 2013 to 2016 he served as Executive Officer for the Applied Vehicle Technology Panel at the NATO Science and Technology Organization. In 2019 Dr. Zimper was appointed as Executive Board Representative Defence and Security Research and, additionally, in 2020 as Managing Director to the Responsive Space Cluster Competence Center at DLR. Furthermore, he is a member of the Science and Technology Board and is an advisor to the FMoD and the Munich Security Conference.

Space Tribes

Differentiating Space Operators in a Crowded Space Community

By Lieutenant Colonel Henry Heren, US Space Force, JAPCC

'Where you stand depends on where you sit.'[1]

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WHO IS WORKING IN SPACE?

CIVILIAN ENDEAVOURS

SCIENCE AND EXPLORATION

European Space Agency (ESA)

National Space Institute at the Technical University of Denmark (DTU Space)

National Aeronautics and Space Administration (NASA)

COMMERCIAL VENTURES

Danish Aerospace Company (Medical)

SpaceX (Launch)

European Space Imaging (Imagery)

INMARSAT (Communications)

MILITARY OPERATIONS

SPACE AS UTILITY

Intelligence

Weather

Communications

Position, Navigation, and Timing

SPACE OPERATIONS

Space Launch

Space Domain Awareness/ Space Situational Awareness

Collision Avoidance

Counter-Space

Electronic Warfare

Introduction

'We have declared space an operational domain for NATO, recognising its importance in keeping us safe and tackling security challenges, while upholding international law,'[2] announced the North Atlantic Council, from London, on 4 December 2019. This recognition has been widely celebrated across the NATO Command and Force Structures and initiated numerous activities. However, generic use of the term Space has caused a great deal of disparate concepts, themes, and pursuits to be melded together even when they have little to nothing in common with one another.

The first of four groups this paper identifies are those focused on exploration and scientific pursuits. While there have been military members to travel into Space, the missions have been focused on continuing humanity's understanding of the planet, solar system, and universe. The second group is comprised of commercial companies seeking to earn a profit by providing various Space-related services such as communications, imagery, and Space launch. The next group are the military members and capabilities utilizing Space-based Data, Products, and Services (DPS) as a utility function in the execution of military operations within the earth's atmosphere. The Position, Navigation, and Timing (PNT) provided by the Global Positioning System (GPS) is a prime example of this utility function. Modern militaries, including NATO, are dependent upon Space-based PNT but are uneducated and unconcerned about the operational mechanics involved with ensuring the service. The final group are the military Space operators, those focused on operating in Space. For NATO, and many of its members nations, this last group is the smallest and yet potentially the most impacted of the groups listed by NATO's recognition of Space as an Operational Domain.

The enthusiasm felt across the communities of interest listed, with regards to the recognition of Space as a NATO Operational Domain, does not mean all those communities are considering Space from the same perspective or with the same goals in mind. This article will discuss the various tribes and expand on the challenges facing NATO as it seeks to develop its recognition of Space as an Operational Domain amidst various interests. The goal being to allow for discussion regarding a way ahead for Space within NATO, informed (at least partially) as to the different perspectives and ambitions.

Civilian Exploration and Scientific Pursuits

Two of the more prominent Space-related exploration and scientific organizations currently in existence are the United States' (US) National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA). NASA's Vision is 'to discover and expand knowledge for the benefit of humanity,'[3] while ESA's mission is to 'to shape the development of Europe's space capability and ensure that investment in space continues to deliver benefits to the citizens of Europe and the world.'[4] Both of these organizations, and others like them, primarily seek to explore and learn. They also exist to promote commercial interests within the US and Europe, respectively, which will provide benefits for their populations from Space-related endeavours.

Organizations focused on exploration and scientific pursuits share some interests with the other groups discussed in this paper, such as advancements in technological capabilities[5], environmental impacts on Space vehicles[6], and congestion of various orbits by operational satellites and debris[7]. However, their interest in these areas is foremost in support to their goal of scientific advancement and exploration.

Civilian Commercial Interests

While initial forays into Space were steps of governments, commercial interests in Space-related activities have recently grown from supporting national aspirations to fully independent commercial interests. Indeed, 'the investment implications for a more accessible, less expensive reach into outer space could be significant, with potential opportunities in fields such as satellite broadband, high-speed product delivery and perhaps even human space travel.'[8] This means that in the 'near term, space as an investment theme is also likely to impact a number of industries beyond Aerospace & Defense, such as IT Hardware and Telecom sectors. Morgan Stanley estimates that the global space industry could generate revenue of more than $1 trillion or more in 2040, up from $350 billion'[9] in 2020. Additionally, the prospect of mining celestial bodies (such as asteroids) is on the cusp of becoming a reality. NASA is planning to launch a spacecraft in mid-2022 at an asteroid identified as '16 Psyche', which has the possibility of 'being worth $10,000 quadrillion if mined,'[10] and amount more than 75,000 times that of the world economy.

While it may be some years before asteroids are successfully mined for commercial benefit, the trend clearly shows substantial growth in commercial Space enterprises with more to come. As with those focused on exploration and scientific pursuits, commercial interests share certain concerns about operating in


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Space. Those concerns are in relation to a bottom-line that separates success and failure based on financial considerations.

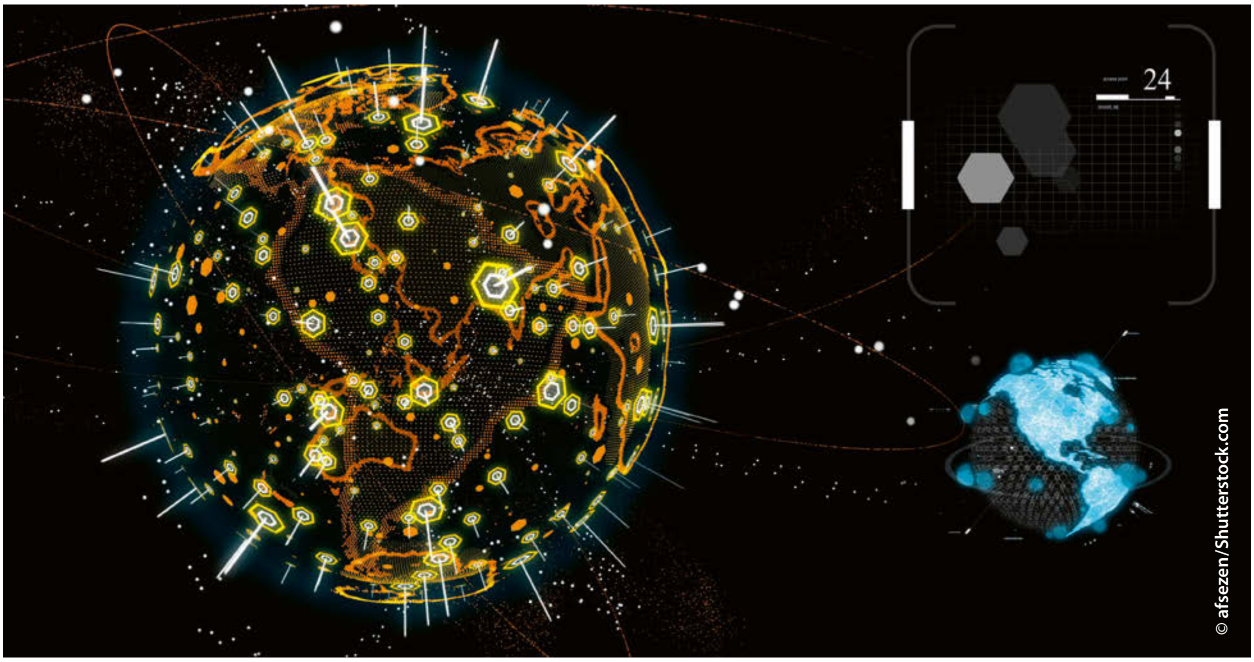
Military Utility Users

For NATO, 'Space is essential to the Alliance's deterrence and defence. Space underpins NATO's ability to navigate and track forces, to have robust communications, to detect missile launches and to ensure effective command and control.'[11] Furthermore, 'Understanding and leveraging the Space domain is critical to NATO military planners and operators'[12] because 'the absence of Space products and services will inhibit the ability of NATO to achieve overall objectives in the most efficient and effective means possible.'[13] As long as NATO does not own or operate any Space-based capabilities it is dependent upon Space-based services provided by the member nations in the form of Space-derived DPS. The new focal point within NATO for the coordination and dissemination of DPS will be the NATO Space Centre[14], located at Ramstein Air Base in Germany.

What is important to understand is that NATO utilizes Space capability-derived DPS to support terrestrial operations. In this sense, Space (the Operational Domain) serves as a utility function, supporting the collection and/or dissemination of DPS to support NATO operations not taking place in Space. The various NATO headquarters, staffs, and operators are only marginally concerned with Space, rather their focus is on ensuring continued access to the DPS which enables their operations within earth's atmosphere. Therefore, the focus in NATO regarding Space has been Space Support in Operations[15], versus Space Operations themselves.

Military Space Operators

The final group this paper will discuss is both the smallest group and yet the group most impacted by NATO's recognition of Space as an Operational Domain. The military members serving in NATO with education, training, and experience with Space Operations currently number around two dozen, spread across the NATO Command Structure (NCS) in ones



and twos. They collaborate under the NATO Bi-Strategic Command Space Working Group (NBiSCSWG), which is co-chaired by two Lieutenant Colonels, one each, from Allied Command Operations and Allied Command Transformation. The NBiSCSWG is tasked 'to increase Collaborative Space Support in NATO operations by studying operational requirements and improving Space education and training'.[16]

This small group of dedicated Space professionals strives to provide to support to NATO operations, education, training, and development of policy and doctrine. Their numbers will soon be bolstered by an influx of staff members into the previously mentioned Space Centre, but it remains to be seen if those staff members will bring Space expertise to NATO or instead come searching for experience to take back to their home nations. The establishment of the Space Centre is a significant undertaking and achievement for NATO, which may be more challenging if it must include extensive education and training for its staff to achieve a basic understanding of Space-related operational considerations.

What will be needed within the NCS, aside from the Space Centre, will be an increased cadre of Space experts to bolster the integration of Space Support in NATO Operations. This integration will require including Space-related education into existing curricula, increased emphasis on Space DPS within NATO training exercises, and further development of policy and doctrine. An important first step may be the development of a NATO Space Policy which can be shared and understood across NATO, as the current Overarching Space Policy (adopted in June 2019[17]) is restricted, and/or the creation of NATO Security Classification Guide for Space so people can know what they can and cannot speak and write about regarding NATO's approach to Space.

Additional leadership, from officers who are educated and experienced Space professionals, is also needed at the various NATO Headquarters. General Officers and Colonels, with years of Space expertise, will have greater access to key senior-level decision-making discussions which will allow them to better promote the growth and understanding of Space within NATO. The senior officers can also provide the appropriate strategic guidance and direction to the staff officers and non-commissioned officers focused on Space-related deliverables within the various headquarters' staffs.

Conclusion

While Space and Space-based capabilities are increasingly utilized by more people and interests, it is important to be able to distinguish the different perspectives and aspirations as NATO collectively integrates Space-related activities and capabilities into daily life and military operations. While there are significant overlaps and shared interests, NATO cannot allow these overlaps to confuse and distract discussions from focusing on the further development of ideas which allow for the exploitation of Space-based, and -related, capabilities for the benefit of the NATO Alliance.

'For NATO, "Space is essential to the Alliance's deterrence and defence. Space underpins NATO's ability to navigate and track forces, to have robust communications, to detect missile launches and to ensure effective command and control."[11]'

General Jeffrey L. Harrigian, JAPCC Director and Commander, Allied Air Command, recently stated, 'coordination with Nations in the space domain is a critical mission as civilian, military, and commercial organizations become increasingly dependent on space capabilities for our safety and security.'[18] That coordination must be informed, not just by an understanding of the existing and emerging technologies and the various operational considerations, but also by the mental framework in which NATO personnel are each working. It is an understatement to say that Space is big. NATO must also recognize that collectively it is piling a great deal of meaning and perspectives into the word Space, and needs to ensure personnel do not speak past one another while utilizing the same terms with vastly different meanings, goals, and context.

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Hypersonic Weapons

The Defining Challenge of Our Time

By Lieutenant Colonel Francesco Esposito, IT AF, JAPCC

Introduction

For most people, hypersonic weapons and aircraft represent yet another 21st century technological breakthrough in which science fiction becomes science fact.[1]

However, hypersonic studies have an extended history stretching back over half a century. In October 1967, William J. Knight, an aeronautical engineer, piloted the X-15 to the official world record for the highest speed ever recorded by a manned rocket-powered aircraft. On that occasion the North American X-15, a hypersonic jet operated by the United States (US) Air Force, flew Mach 6.7 at 102,100 feet. Following the success of this hypersonic vehicle, the US Air Force focused on developing technologies to enable the use of hypersonic speeds across a range of applications. A series of hydrocarbon-fueled direct-connect scramjet ground tests were successfully completed in the National Aeronautics and Space Administration's (NASA) Langley Arc-Heated Scramjet Test Facility in 2011.[2]

This new variety of engine was tested on the Boeing X-51 'Waverider' which flew a few times between 2010 and 2013 and demonstrated the potential viability of a scramjet-powered vehicle for weapon applications.

This article aims to convey to the reader a brief overview of the technology itself and provide a few thoughts regarding various scenarios and threat implications these weapons could create in future conflicts.

Today, press reports indicate that the US, Russia, and China are leading the race to develop hypersonic glide and cruise missiles to penetrate defended airspace. China and Russia are reportedly conducting tests of these high-speed weapons as an asymmetric response to American military superiority. Russia, who is working on several hypersonic projects, such as 'Avangard' and 'Kinzhal', has successfully tested the hypersonic anti-ship cruise missile 'Zircon', which has already been assigned a NATO reporting designation of SS-N-33. This indicates that the missile is expected to come into service soon and that the Alliance is treating the reports of its development fairly seriously. The 'Kinzhal' and the 'Avangard' are reported operational[3] while the 'Zircon' is still in the development phase. China is fully involved in this race as well. In his testimony to the Senate Armed Services Committee on 13 February 2020, US Air Force General Terrence O'Shaughnessy, Commander of US Northern Command (USNORTHCOM) and North American Aerospace Defense Command (NORAD), noted that China is testing a Hypersonic Glide Vehicle (HGV) similar to the Russian 'Avangard' system. The state-owned China Aerospace Science and Technology Corporation (CASC) claimed in August 2018 that it had successfully developed and tested China's first experimental hypersonic waverider[4], called 'Xing Kong 2' (or Starry Sky-2). Some reports indicate that the Starry Sky-2 could be operational by 2025[5]. Another Chinese boost-glide weapon project is the DF-ZF, which recently has been shown on a Dong Feng DF-17 missile during a parade in China, after multiple test shots between 2014 and 2018.[6]

The US Air Force is working on multiple programs. One of these is the hypersonic Air-Launched Rapid Response Weapon (ARRW) produced by Lockheed Martin's Space Systems division. 'The rocket-boosted ARRW is one of the air-launched hypersonic missiles publicly known to be undergoing testing by the Pentagon, which considers the project a necessary step to maintain an edge over near-peer competitors China and Russia.'[7] 'The work will be run out of Orlando, Florida, and is expected to be complete by the end of 2022 – when the missile is expected to reach operational capability.'[8]

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Other countries are also beginning to show an interest in hypersonic weapons technologies. France, India and Japan are close behind the first three, while Australia and other European countries are developing the component technologies for ostensibly civilian purposes such as Satellite/Spacecraft launch and repair, deliveries to the space station and space tourism

What is Hypersonic?

Airspeed is a measurement of a plane's speed relative to the air around it and is frequently expressed in terms relating to the speed of sound. The speed of sound is set at 'Mach one' which is approximately 340 m/s (761 mph) or 1225 km per hour at sea level. Commercial airliners fly right under Mach one at subsonic speeds, while modern fighters can fly supersonic at Mach two or three. By definition, hypersonic weapons can travel at least five times this speed.

Anything travelling Mach five and above is considered hypersonic. The technology, which is just now emerging, enables sustained hypersonic flight for a significant distance and time. This is typically achieved by employing scramjet (Supersonic Combusting Ramjet) engines. The scramjet is a new modified version of the ramjet. Scramjet takes the oxygen needed by the engine to combust from the atmosphere passing through the vehicle instead of from a tank onboard.[9] These engines have fewer moving parts than the turbofan engines which can be found on conventional jet planes. They require an initial speed of approximately Mach 4 to ignite the fuel and generate thrust.

This is the reason why a boost engine is mandatory. However, these engines are not mature yet. According to a US Air Force Scientific Advisory Board report, they were expected to reach an adequate level of maturity by the end of 2020 in order to shift the focus of the economical efforts from technology development towards product development.[10] 'Currently, no hypersonic efforts are in production. The US Air Force's Air-launched Rapid Response Weapon is expected to be the first to achieve a residual operational capability where production decisions can be made after fielding at the end of fiscal year 2022.'[11]

Emerging Weapons

The main reason for the development of hypersonic weapons is to hold opponents' mobile targets at risk and to improve the ability to penetrate advanced integrated air defence systems. It is common understanding that these new weapons could have significant impact on strategic stability.[12]

There are two types of weapons emerging: Hypersonic Cruise Missiles (HCM) and Hypersonic Glide Vehicles (HGV).

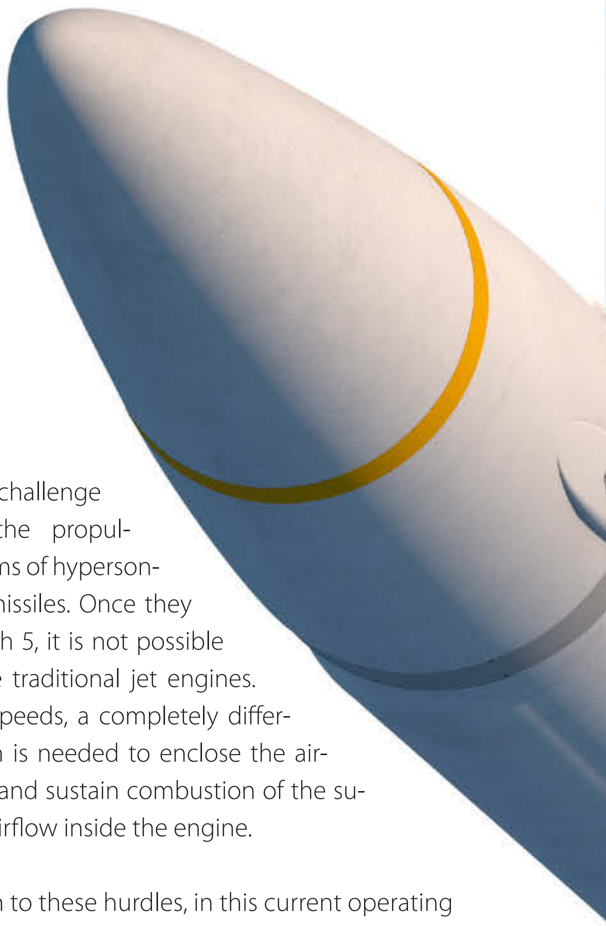
HCM's are powered to their targets using the advanced propulsion system described earlier, the scramjet. They are very fast and manoeuvrable, hence defenders may have just a few minutes from the time they are launched until they strike their targets. The HGV is placed on top of rockets launched to extremely high altitudes where it is released at the appropriate altitude, velocity, and flight path angle, and enabled to glide and manoeuvre to its target. China's 'Xing Kong 2', Russia's 'Avangard', and the American Tactical Boost Glide (TBG) and ARRW projects, are all example of HGV, which maintain stability to fly along and to manoeuvre, keeping their targets hidden until the last few seconds of flight.[13]

Challenges to Hypersonic Capability

There are four primary hurdles to the development of hypersonic weapons: manoeuvrability, material, speed, and communication.

First, the aerodynamics and flight controls for flight at hypersonic speeds are a significant challenge; hypersonic airflow is different from supersonic airflow in that it is nonlinear and experiences different physical effects.

The second challenge is material science. 'The faster the vehicle flies both the pressures and temperatures rise exponentially.'[14] All of this 'requires materials that can withstand high temperatures over long periods of time.'[15]



The third challenge involves the propulsion systems of hypersonic cruise missiles. Once they reach Mach 5, it is not possible to use the traditional jet engines. At these speeds, a completely different design is needed to enclose the airflow path and sustain combustion of the supersonic airflow inside the engine.

In addition to these hurdles, in this current operating environment, data exchange also appears to be a unique technical challenge. 'Basic operations, like communications, become significant during hypersonic flight. Personnel need continuous connectivity to operators and decision makers through global communications and sensor systems that can operate within these high-speed environments'[16] as stated by Scott Greene, executive vice president of Missiles and Fire Control (MFC) for Lockheed Martin Corporation.

Is NATO Prepared to Counter Hypersonic Weapons?

Hypersonic systems provide advantages in terms of ***speed to target, manoeuverability*** and ***survivability*** to reach well-defended targets.[17]

High speed means less warning time. Until now, NATO has been reasonably confident that its collective intelligence capabilities would alert member nations to limited enemy aggression.

HGVs and cruise missiles can ***manoeuvre*** hundreds of kilometres in cross-range during their glide phase. Therefore, even if these weapons can be tracked, their targets will remain uncertain until late in the vehicles' trajectory.

Given the high speeds and short timelines involved, hypersonic weapons have the potential to ***make defensive missiles less effective*** than they might be against non-manoeuvring 'ballistic' targets.

The combination of the manoeuvrability and the speed makes hypersonic missiles unpredictable and extremely difficult to defend against. 'This would enable a weapon apparently on a ballistic trajectory toward Los Angeles to manoeuvre and strike New York.'[18]

In addition, because of their high kinetic energy, they would not even require heavy warheads to be able to penetrate heavily hardened targets like Intercontinental Ballistic Missile (ICBM) silos. This feature elevates hypersonic weapons above the tactical level because they pose a strategic challenge.

There are, at the moment, no existing countermeasures.[19] 'We don't have any defence that could deny the employment of such a weapon against us', Air Force General John Hyten, Commander of US Strategic Command, told the Senate Armed Services Committee on the 20 of March 2018[20]. One year later, 'If war breaks out tomorrow, we're probably not going to kill hypersonic boost-glide missiles', Mike Griffin, the Pentagon's undersecretary of research and engineering, said during a speech[21].

Lockheed Martin © 2021

The compressed timeline associated with hypersonic attacks – whether ballistic, boost-glide or cruise – also contributes to crisis instability, because there will be precious little time for careful decision-making in the midst of an attack.

Most countries use the 'OODA Loop' (see Figure 1) when they make decisions about whether they have to respond to a threat or not. Because of the speed of hypersonic weapons, the process has to work on compressed timelines, leaving less room for mistakes and increasing the possibility to miss or fail at a critical decision-making step.

Possible Solutions and Implications

'Deterrence' and 'Decision delegation' are among the most likely solutions to adapt to this new threat.

The first implies that people could become more 'trigger happy'. The constant need to dissuade the adversary by proving that we are ready and able to attack and this in conjunction with the compressed time frame to take a decision, makes people much more likely to want to be the first to strike as opposed to the second, in order to preserve a second-strike capability.

The delegation of the decision, on the other hand, implies that if one cannot defend against a 'decapitation', one has to distribute Command and Control (C2) of the weapons to the field, to the military or autonomous or automated systems rather than to the national political leaders which raises the risk of an accidental strategic war.

Although there are no current countermeasures in place, technologies such as directed-energy weapons and terrestrial, sea and space-based interceptors, will be likely candidates for an effective defence against hypersonic missiles together with cyber-attacks on the enemy's C2 systems to disrupt their OODA loop.

'Targeting the supporting network kinetically and through means such as cyber and electronic attacks could significantly degrade the operational effectiveness of long-range hypersonic weapons'[23] due to the fact that a robust Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR) network is required.

'He, who can handle the quickest rate of change, survives.'
Colonel John Boyd[22]

Ultimately, arms control measures designed to limit the presence and the study of hypersonic weapons could be devised. Arms control is the traditional approach to ameliorating the destabilizing consequences of novel weapons.[24] The New Strategic Arms Reduction Treaty (New START), a strategic offensive arms treaty between the US and Russia, does not currently cover HGV and HCMs. However, some legal experts hold that the United States could raise the issue in the Bilateral Consultative Commission (BCC), which oversees implementation of the treaty, of negotiating to include hypersonic weapons in the New START limits. The goal is to avoid the proliferation of hypersonic technology not just to rogue nations but also to nations with regional hegemon aspirations. A kind of non-proliferation act addendum or amendments to

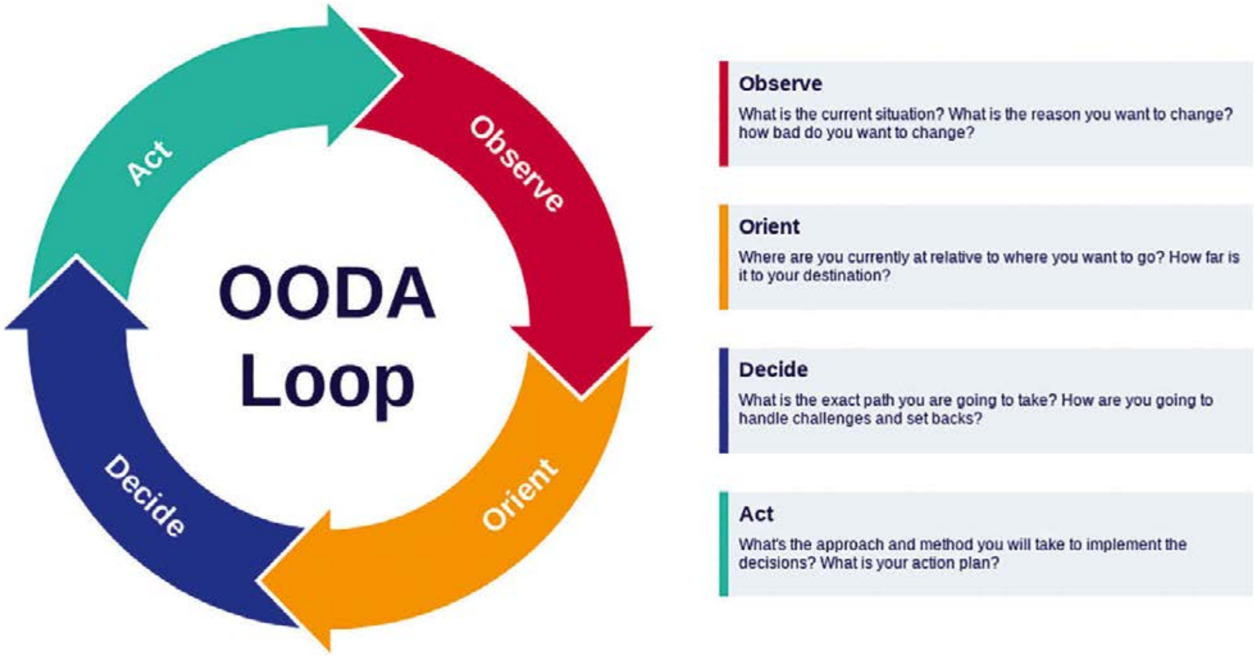


Figure 1: The OODA Loop is a four-step approach to decision-making.

the missile technology control regime, supplemented with some controls on the export of hypersonic components could be the solution.

'Preventing the emergence of new and destabilizing strategic weapons is a vital task for the international community in our shared endeavour to preserve international peace, security and stability.'[25]

Conclusions

It is clear that the overall scenario has changed. War evolves, several States are actively pursuing novel long-range manoeuvrable weapons, most significantly hypersonic weapons. Research in this field dates back to 1967 but accelerated in the 2000s. Today, a global hypersonic arms race is underway, challenging geopolitical order and undermining existing strategic air and missile defence systems.

Negotiating some sort of international agreement to not chase these technologies for military purposes could solve the problem. 'The key is time.' Governments move slowly, and hypersonic technology development is gradually spreading and becoming embedded in government programs.

Recent reports of successful hypersonic missile tests demonstrate that these capabilities will be fielded much sooner than we thought, forcing a global reassessment of traditional deterrence models.

'Hypersonic systems provide advantages in terms of speed to target, manoeuvrability and survivability to reach hardened and well-defended targets.'[26] The combination of the manoeuvrability and the speed makes hypersonic missiles more unpredictable and extremely difficult to defend against.

Because of the speed of hypersonic weapons, the possibility to miss or fail in a decision-making step is reasonably high. Therefore, 'Deterrence' and 'decision delegation' are among the most likely possible solutions if arms control fails, but both have drawbacks.

Therefore, nonproliferation discussions should begin as soon as possible, as there is probably less than a

decade available to substantially hinder the potential proliferation of hypersonic missiles and associated technologies.[27]

As a result, a state facing a hypersonic missile threat must make the best of a bad situation, effectively forced to choose the lesser of two evils.

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joined the Italian Air Force in 1990, joining the Italian Air Force Academy in Pozzuoli (Italy). He was trained with the US Air Force SUNT program in Randolph AFB (TX) and subsequently graduated as a Tornado Navigator/Weapon System Operator in Cottesmore (UK) in 1996. As an aircrew with 156° Tornado Sqn, and as an instructor with 102° Tornado OCU Sqn he participated in the flying Operations in Bosnia and Kosovo. Between 2008 and 2012, he served as ATO Coordinator and Chief Strike cell in the Combined Air Operation Centre in Uedem (Germany) contributing, as an ATO Coordinator, to the Operation Unified Protector in Libya. Currently, he serves as JAPCC Precision-Guided Munition Expert.

Air Power: The 6th Generation of Aircraft

By 2nd Lieutenant Raffaele Rossi, IT AF, Air Force Academy

Introduction

In addition to the existence of conventional threats, today the geopolitical scenario offers very complex hybrid challenges.

Borders have returned to the centre of world politics, just like a century ago on the eve of the Great War. Moved, cancelled, or contested from the Middle and Far East to Eastern Europe shows how great crises are changing the balance of power and national geography.

Faced with so much instability the military instrument has become increasingly important and air power, the result of the evolution of science and technology, has played a leading role, demonstrating its validity even in an asymmetrical environment. The ability to hit an opponent with extreme precision while minimizing collateral damage has significantly contributed to the achievement of the desired end state in many operations.

NATO's aerospace power provides nations and national political leaders with an unparalleled tool of responsiveness and flexibility. However, there is a significant risk that NATO may not have the right capability, in terms of aerospace power, to address future security challenges. This necessitates a look by NATO and other European nations at ways to accelerate research, development and acquisition of fifth and even sixth-generation systems.

Air Power Today and Tomorrow with Space, Cyber, and Hypersonic Components

In 2014, following the Ukrainian crisis, Russia reminded the United States (US) that it is still a great nuclear power, reversing the agreements reached by Reagan and Gorbachev. China has repeatedly expressed its desire to be the dominant power in the South China Sea and does not want US interference. Russia and China have been working together for some time in both the technological and diplomatic fields and supported countries considered hostile by the US (Iran and North Korea). The two Asian superpowers have been subjected to sanctions of various kinds by the US and this has reinforced the 'sentiment' of working together in an anti-US function. Technology, in today's world, is not to be considered a monopoly. When a country expresses technological superiority, the opposing party will do everything to limit the consequences of such superiority.[1]

During the Cold War, the deterrent power exercised by the two opposing blocs was fundamental and the development of missile systems capable of targeting opposing defence and attack systems was one of the pillars capable of shaping the international balance until recently.[2]

The US developed various anti-ballistic missile systems, considered a threat by Russia for its deterrent capability, especially taking into account the ongoing work to improve Russian missile defence systems.

The research in the field of hypersonics filled the existing gap (Mach 5 or higher). The Russians developed the 'Avangard' hypersonic missile system (Mach 20) to counter US' anti-missile capability, assessed as destabilizing the global balance of power. The system has been in the deployment phase since 2020.

The birth of hypersonic weapons has given rise to the need to develop new defence systems.

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Since the invention of flying, the field of speed applied to aircraft and missile has been a frontier that man is trying to push ever further.

The objective has materialized thanks to the progress made in the study and research of new materials and propulsion systems.

Hypersonic aircraft fly through the atmosphere creating intense friction with the surrounding air as they travel at speeds above Mach 5. Developing structures that can withstand high temperatures and high speeds is a technical challenge, especially for leading edges that bear the weight of the heat.[3]

To address this, Defense Advanced Research Projects Agency (DARPA) announced its Materials Architectures and Characterization for Hypersonics (MACH) programme in early 2019.[4] The programme seeks to develop and demonstrate new design solutions and materials for sharp, stable, and cooled leading edges for hypersonic aircraft.

Regarding propulsion, the creation of the Advanced Full Range Engine (AFRE) programme launched by DARPA includes a hybrid propulsion system paving the way for reusable hypersonic flight. The programme seeks to develop a new aircraft propulsion system that can operate at subsonic, supersonic and hypersonic speeds.

In the decade-long quest to develop reusable aircraft able to reach hypersonic speeds of approximately 5,300 km/h (Mach 5) and above, engineers have faced major challenges. Worth mentioning the maximum speed of traditional turbine engines, a reaction that reaches the limit speed at about 2.5 Mach, or the fact that hypersonic motors, such as scramjets, cannot operate at speeds lower than 3.5 Mach.

AFRE aims to explore the combined cycle turbine engine concept, which would use a turbine engine for low-speed operations and a dual-mode ramjet for high-speed operations. The two components of the hybrid engine would have in common a forward-facing air intake and a rear-facing exhaust nozzle to release thrust.[5]

If on the one hand the US has been constantly committed, the surprise comes from its geopolitical competitors, which now seem to own these new technologies.

In May 2019, China tested the first hypersonic aircraft named Jiageng-1 developed by the Xiamen University after more than ten years of research.[6] The aircraft is capable of reaching speeds between Mach 5 and Mach 7, thus making it invulnerable to the most sophisticated anti-aircraft defence systems in use.

The Jiageng-1 adopts a 'waverider' type design, that improves its supersonic lift-to-drag ratio by using the shock waves generated by its own flight as a lifting surface, a phenomenon known as 'compression lift' similar to that of other prototypes such as the Boeing X-51 (tested from 2010 to 2013 and capable of reaching Mach 5.1, 5,400 km/h). Additionally, it allows improving the lift ratio/resistance by means of the in-flight generated shock waves.

This aircraft outperforms Western competitors for its ability to switch from supersonic to hypersonic flight with ease and lower fuel consumption. These results were possible thanks to the discovery of new materials capable of resisting temperatures above 3,000 °C.

The developments that hypersonic technology may bring in the future, especially in the military field, warrant great innovation.

China is determined to have a leading position in the sector and this has prompted the Pentagon to increase funding dedicated to hypersonic capabilities.

DARPA's Falcon project aircraft are in the making, requiring substantial financial resources of around 320 million USD.

Technological discoveries have been able to relaunch the eternal duel between defence and offence.

The world is now facing a similar situation like the advent of nuclear weapons after the Second World War: weapons based on new technologies that make current defence systems obsolete and inefficient.

Nuclear weapons might be the primary beneficiaries of the hypersonic developments.

Hypersonic speeds undermine traditional decision-making cycles based on the Observe, Orient, Decide, and Act (OODA) loop that currently involve longer response times than the time needed by hypersonic weapons to reach the target. The different types of previous and extant defence weapons might become insufficient. Due to the speed of the hypersonic threat, any enemy target data acquired, regardless of how great the distance, will become inefficient for targeting purposes due to the reactive nature of the weapon. The only efficient observation and reconnaissance capability will be the offered by low-earth orbit satellites.


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Therefore, the technological innovation of hypersonic aircraft and weapons is of fundamental importance. It initiates a new form of conflict, which emphasizes the space domain's importance.

Progressions in hypersonic technology bring control over the space domain, leading to inherent advantages in the sister domains of air, land, and sea.[7]

Developing hypersonic technologies implies a considerable economic effort with investments that not all countries are ready to face.

In the light of future technological innovations, it is necessary to look at a sixth-generation of aircraft, capable of detecting hypersonic threats at range, assessing them quickly using Artificial Intelligence (AI) and networked support, and engaging them with weapons designed for the purpose.

The US is working on a replacement for the F-35; United Kingdom (UK), Italy, and Sweden have signed agreements for the new Tempest system; France and Germany are planning the development of the Future Combat Air System (FCAS) and Turkey is planning the TF-X.

The new generation of aircraft will no doubt have to take into account the leaps forward in the speed sector and new hypersonic ballistic systems.

In complex systems, situational awareness built on real-time theatre information is the starting point for the analysis and for the consequent decision-making processes.

With the cyber revolution underway, in order to maintain high situational awareness and rapid decision-making processes, the use of AI generating tasks automation and behaviour prediction is consequential.

The US has already outlined some of the requirements for the sixth-generation aircraft.[8]

In particular, they are developing:

- digital engineering, to accelerate the construction and industrialization processes; *'in the 21st century, at current rates we will not experience 100 years of progress but 20,000 years'*;[9]
- advanced artificial intelligence, which can provide required targeting data in seconds;
- new kinetic and non-kinetic precision weapons;
- an expansion of the network for combat platforms, enabling real-time data exchange to achieve information and intervention dominance;
- new nanotechnologies applied to materials to reduce the radar and infrared signature;
- new engines with the application of the 'third air stream' that provides an extra source of airflow to either improve propulsive efficiency and lower fuel burn or to deliver additional airflow through the core for higher thrust and cooling.

The new platforms will be part of a complex information system made up of many nodal points capable of continuously acquiring and exchanging data and executing decisions. Being nodes of a network will give complexity and resilience to the military system synchronizing forces across domains, with or without direct contact with those forces, providing new capabilities for the application of operational art across air, space, and cyber domains.

Italy, which shares a part of its defence industry with the UK, has worked towards the most logical solution, but has also underlined the need not to fragment the industrial potential as happened with Eurofighter, Gripen, and Rafale programmes.

Having more types of aircraft in the Alliance undermines interoperability and synergy between allies by reducing the integrated logistic support, whose inefficiency will negatively impact the military capabilities available in the operational theatre.

Comparing the Gross Domestic Product (GDP) of the countries participating in the Tempest, FCAS, Tornado and Eurofighter programmes, the following elements can be detected:


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- The Tornado counts on Germany, Italy and the UK whose GDPs total approximately 8.2 trillion USD (2017 values).
- Eurofighter with Germany, UK, Italy, and Spain availed of 10.5 trillion USD.
- The FCAS aircraft, on the other hand, will be able to leverage 7.5 trillion USD.
- The Tempest aircraft contemplates a potential of only 5 trillion USD aggregate.[10]

The development of the sixth-generation aircraft might face limitations due to reduced budgets and probably will not have economic repercussions as in the F-35 programme.

Merging the two European projects, Tempest and F-CAS, improvements are to be expected. In this respect, the financial base would be comparable to China's 12.2 trillion USD of comparable GDP. If, on the other hand, the projects were to encompass all the countries of the European Union, it could count on 18.5 trillion USD, close to the US GDP of 19.4 trillion USD.[11] Undoubtedly, the effects of the Covid-19 crisis will have an impact on the projected financial estimates.[12]

Conclusion

A keyword emerges from this picture, namely: fragmentation. An antithetical word to that of 'Union', making Europe a giant with feet of clay on various fronts, from foreign, domestic, industrial and economic policies.

A unity of purpose and a unity of views is required, and perhaps a single European defence industry.

Faced with the uncertainty and insecurity of the future, it is necessary to remain united.

The military instrument is fundamental to guaranteeing security. As history has shown, the aerospace power provides nations and national political leaders with an instrument of unparalleled responsiveness and flexibility, and is always in constant evolution.

Europe now has set the stage for a turnaround through the Next Generation European Union[13] tool that will be implemented through three pillars: helping member states to recover, reviving the economy and supporting private investments focused on research and innovation. European leaders should take advantage of this reset opportunity and find a way to knit Europe's defence industries into a more interconnected system with enough funding and cohesive technical and production capability to tackle the challenges of hypersonic threats and sixth-generation systems.

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2nd Lieutenant Raffaele Rossi

In 2012, he joined the Air Force, graduating in 2015 from the NCO Academy in Viterbo, with a bachelor's degree in Organizational and Management Sciences. In 2015, he was deployed in Pratica di Mare Airbase where he worked as aircraft technician and attended several courses at Leonardo Company.

In 2020, he graduated from Niccolò Cusano University with a Master in International Relations. In November 2020, graduated at the same University with a Master's in Geopolitics of Security, with a thesis on 'Space Safety: Air Power up to the 6th generation'.

Presently, he is an Italian Air Force officer, assigned to the Air Force Academy in Pozzuoli.

Leveraging the Alliance's Effort in Fighter Aircraft Design

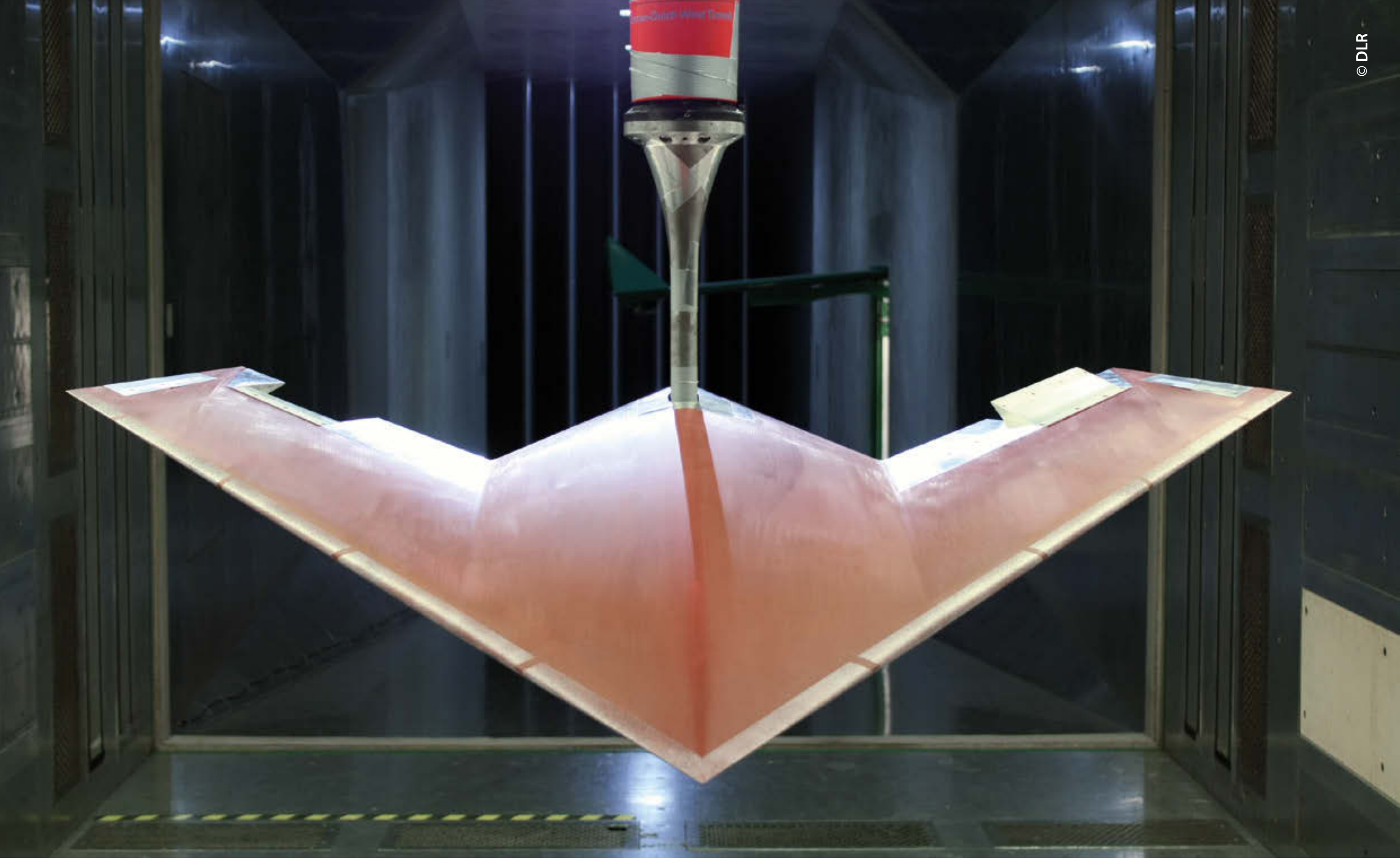
Multinational Task Groups on Fighter Aircraft Design and Assessment

By Dr.-Ing. Andreas Schütte, German Aerospace Center (DLR)
By Prof Dr Russell M. Cummings, United States Air Force Academy (USAFA)
By Dipl.-Ing. David Klaßen, NATO Science and Technology Organization (NATO STO)

Introduction

The NATO Science and Technology Organization (STO) has the objective to foster and improve the interchange of information relating to military research and development between the NATO nations. It is a follow-on organization of the Advisory Group for Aerospace Research and Development (AGARD) founded in 1952, which represented a pioneering and successful experiment in scientific cooperation among NATO nations. The founder and first chairman of AGARD, Dr Theodore von Kármán, dedicated his life to the enhancement of understanding and cooperation among scientists of different nations.

In 1998 a new organization was formed by the merging of AGARD and the Defence Research Group (DRG) into the Research and Technology Organization (RTO), which was transferred into the Science and Technology Organization (STO) in 2012. By that time,



NATO STO established coverage of a broad spectrum of military research and technology topics, consolidating several domains like land, sea and air vehicle technologies, as well as military systems, medicine, electronics, and simulation.[1]

This article provides insights of the facilitation of multinational research and technology development under the umbrella of NATO STO by presenting an example of the effort which the Applied Vehicle Technology Panel (AVT) is contributing to the alliance. AVT focuses on platforms and platform technologies for land, sea, and air vehicles, and since AVT is an organization of voluntary contributors, the research itself is not funded by NATO but by the participating nations. This leads to the fact that the nations themselves suggest the research topics. Hence, AVT's programme of work follows the aim for receiving a deeper understanding of physics and technologies, for sealing technology gaps within the nation's own research programmes, and for fostering new ideas for the future. AVT is using the leverage of working in a multinational environment, where knowledge exchange happens and enablers are created, like test campaigns or field trials that would not have been realized in any single nation's effort. The general working format of AVT is organized around major semi-annual meetings. During those AVT panel business weeks, various events like workshops and symposia on different topics are conducted, and currently more than 40 research task groups are meeting to discuss and coordinate their efforts. AVT is guided by a leading panel and technical committees, observing and supporting the technical programme of work.[2]

NATO AVT Research Task Groups on Fighter Design and Assessment

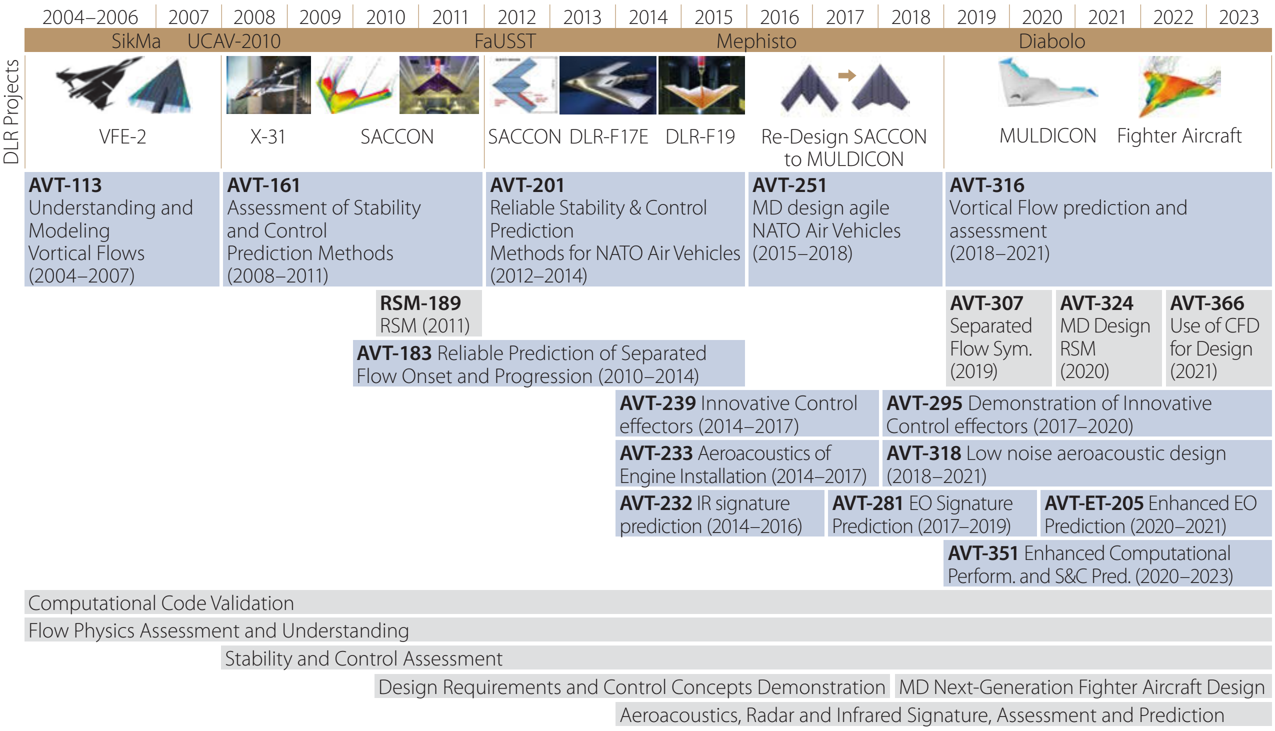
One of the current challenges for AVT to overcome is the understanding and prediction of fighter aerodynamics, as well as the development of reliable overall computational design methods. Therefore, for almost 20 years, AVT tasks groups have been dealing with the development of experimental and numerical methods, as well as tools to design and assess modern fighter aircraft. Recently, holistic design capabilities were addressed in order to provide a dedicated combination of methods and tools, which can lead to an optimal exploitation of their capabilities. Following the higher goal of leveraging the individual nation's efforts, AVT has picked up that challenge. The following chart gives an example by DLR (German Aerospace Center) of how the national research programme is connected to NATO AVT activities and leverages the multilateral scientific contributions. The figure illustrates the type of target configurations focused on by the national military research projects at DLR along the top line. AVT's related task groups and workshops are shown in the central work stream, while the bottom line provides a brief description of these core topics: Computational code validation, flow physics assessment, stability and control assessment, design requirements and control concepts design, multidisciplinary fighter aircraft design as well as design issues regarding aeroacoustics, infrared and radar signature.

The way NATO AVT research contributes to enhancing the alliance's military capabilities, and supports the closing of technological gaps between its individual nations, is described by AVT research task groups dealing with the design and performance assessment of air vehicles and air vehicle technologies.

AVT-161 & AVT-201: Setting the Foundations for a Multinational Fighter Aircraft Design

One of the major tasks within NATO AVT task groups in the past has been to improve the understanding of the flow physics of high angle of attack aerodynamics of fighter aircraft, as well as performance prediction and assessment, especially stability & control characteristics predicted by high-fidelity numerical methods. This approach has always corresponded to various national research programmes among NATO nations. One of the major initial task groups was AVT-161 on 'Assessment of Stability and Control Prediction Methods for NATO Air and Sea Vehicles'. AVT-161 aimed to establish the ability to accurately predict static and dynamic stability characteristics of air and sea vehicles using Computational Fluid Dynamics (CFD) methods to enhance vehicle design methodology. The scope was to assess state-of-the-art CFD methods for predicting static and dynamic stability characteristics of military vehicles in the air and sea domains, and identify areas requiring further

Activities Related to Combat Aircraft Design and Performance Assessment

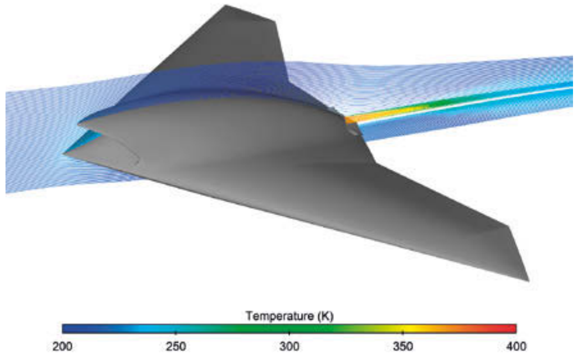


development. This required sufficient experimental validation data to assess the ability of physical modelling to capture the nature of the flow physics of unsteady and off-design fluid dynamics processes for NATO air and sea vehicles. The target air vehicle to demonstrate the task accomplishment was a generic unmanned combat aerial vehicle (UCAV) configuration called SACCON – 'Stability and Control CONfiguration'.

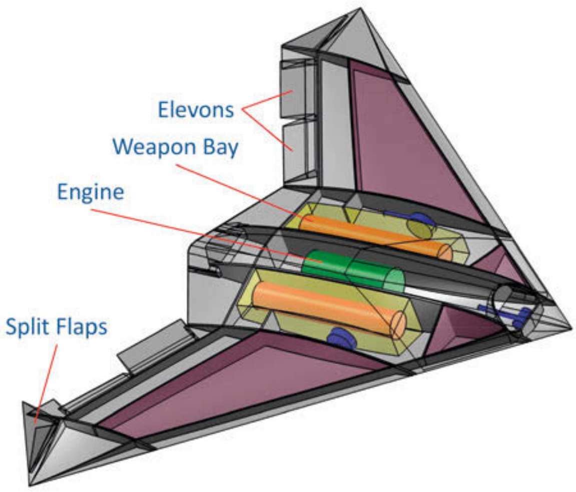
AVT-161 found that CFD could adequately predict the static stability characteristics for air and sea vehicles. However, for dynamic manoeuvres with vortex-dominated flow fields, the CFD predictions still needed to be improved. Several investigations showed that dynamic stability characteristics could be predicted within engineering accuracy, but the detail and physical nature of the flow still requires an experimental approach used in an integrated fashion with the CFD. It was also shown that non-linear system identification methods could make a valuable contribution to the computational effort, as they are able to identify areas of significant non-linearity without running an overly large number of CFD predictions. There is still a high demand for accurate and efficient methods to predict the performance of military air and sea vehicles, which led to the formation of the follow-on task group AVT-201 for the air vehicles domain.[3]

In AVT-201, the investigations were extended to the design and estimation of control device effectiveness for highly-swept, low-observable UCAV configurations. The generic SACCON configuration was extended with control devices, and additional experiments were conducted at a wider range of subsonic and transonic speeds. An additional task of AVT-201 was to transfer the knowledge base to full-scale applications.

AVT-201 was an additional element of a continuous research programme within AVT evaluating the aerodynamic performance of military air vehicles. This comprised essential fundamental research topics as well as programmes dealing with the assessment of fully-equipped military aircraft configurations. These continuous activities eventually provided the tools to establish a reliable design task to conduct a new design based on the application of computational methods.[4]



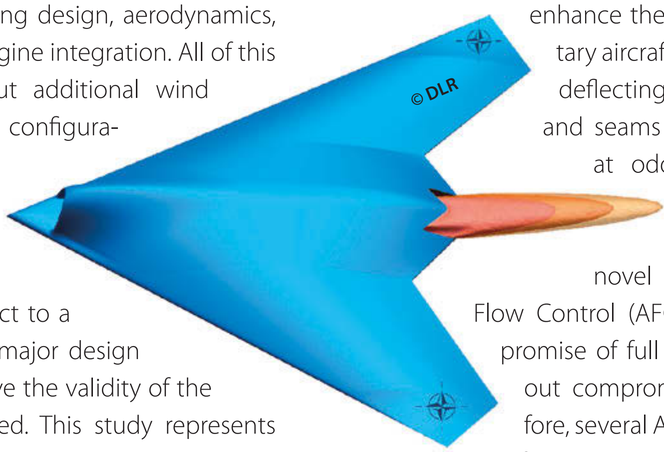
AVT-251, FOI M-Edge, Mach=0.80, V=236 m/s, AoA=2.0°, AoS=0.0°



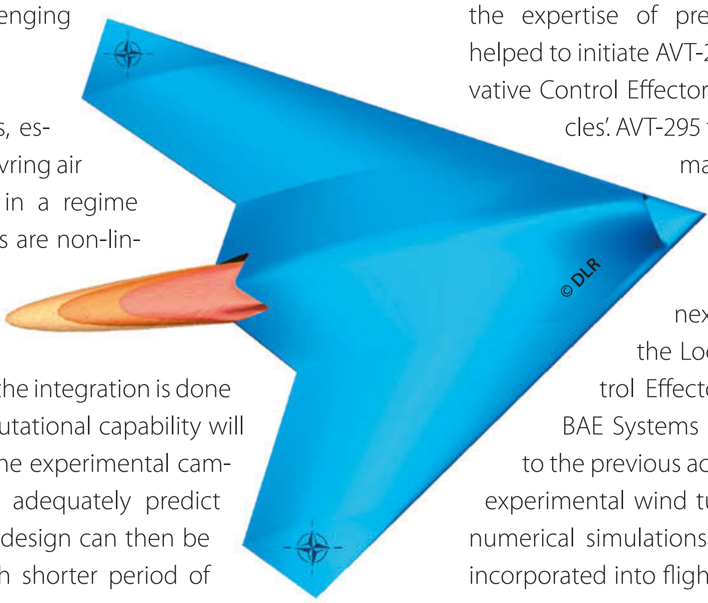
AVT-251: Evolving the Multidisciplinary Approach

These new requirements led to the formulation of AVT-251, which was established in order to accept those challenges. The plan was to perform a multidisciplinary redesign of the SACCON configuration towards a realistic aircraft concept within three years. The group would deal with non-linear aerodynamic flow physics, control device strategies for the medium to high angle of attack flight regimes, and with the design aspects regarding propulsion systems and signature constraints – everything relying purely on CFD and other numerical methods. However, it became clear from the start that a comprehensive investigation covering all relevant aspects of the design would be beyond the scope of the group. Instead, AVT-251 focused on the available resources and partners for some of the most critical aspects, and then linked everything together using conceptual aircraft design methods.

Within AVT-251, the main achievement was to demonstrate that the UCAV demonstrator MULDICON ('Multidisciplinary-Configuration') was able to conduct specific mission requirements that were typical for an advanced, agile UCAV configuration. Design trade studies were conducted within the framework of multiple groups, including design, aerodynamics, controls, structures, and engine integration. All of this was accomplished without additional wind tunnel testing of the new configuration.



Although the disciplinary spectrum was not comprehensive with respect to a fully approved design, all major design disciplines required to prove the validity of the demonstrator were involved. This study represents a good example of how modern design and analysis tools can streamline the design process, as well as being able to come up with a feasible configuration within a reasonably short period. The MULDICON configuration has similarities to a number of other modern UCAVs, and represents a feasible design with controllable flight characteristics at angles of attack that make the configuration agile and capable of fulfilling more challenging mission profiles.



Military applications, especially for manoeuvring air vehicles operating in a regime where the dynamics are non-linear, require an integrated approach of computation and experiments. If the integration is done correctly, the computational capability will be able to reduce the experimental campaigns required to adequately predict the flow. A feasible design can then be achieved in a much shorter period of time and for less expense. The results of AVT-251 showed that this approach was feasible, although certain supporting technology areas would still need to be improved.[5]

AVT-239 & AVT-295: Exploitation and Application of the Acquired Knowledge

In parallel to the above-mentioned activity, AVT-239 focused on the redesign of UCAV control systems to enhance the survivability of future military aircraft. Legacy approaches, using deflecting surfaces that open gaps and seams in the aircraft surface, are at odds with the demand for enhanced survivability. Within the task group, novel approaches using Active Flow Control (AFC) technology offered the promise of full aircraft flight control without compromising detectability. Therefore, several AFC technologies were identified, developed, and assessed against key vehicle performance and vehicle integration criteria (complexity, maintainability, reliability). The goal was to identify the technologies that minimized the reliance on conventional control surfaces during different portions of the vehicle mission profiles.

These expanded technical requirements, along with the expertise of previously mentioned activities, helped to initiate AVT-295 on 'Demonstration of Innovative Control Effectors for Manoeuvring of Air Vehicles'. AVT-295 tested the aerodynamic performance of these technologies, during a representative ingress mission phase, on two platforms representative of next-generation tailless aircraft, the Lockheed Martin 'Improved Control Effectors'-ICE configuration and the BAE Systems MAGMA configuration. Similar to the previous activities, AVT-295 first combined experimental wind tunnel testing and high-fidelity numerical simulations. Aerodynamic data was then incorporated into flight dynamics simulations, where flow control technologies were used to provide flight control in lieu of conventional control surfaces. Eventually, the technology was applied to the two corresponding aircraft demonstrators in order to prove the concept in flight tests.

The flight demonstration programme successfully confirmed the feasibility of using novel control technologies to stabilize and manoeuvre a tailless vehicle. This was accomplished not only in terms of performance, but also by identifying the steps and barriers of the implementation into a realistic aircraft. Furthermore, the approach of AVT-295 increased the confidence in the modelling and prediction methods when applied to full-scale vehicles.

AVT-295 flight testing led to many important results, including the conclusion that the technology was 'feasible and reasonable' for flight control. A direct implication of these results was the announcement in August 2019 by the Defense Advanced Research Projects Agency (DARPA) of its latest request for new ideas in the arena of flight controls. DARPA established the Control of Revolutionary Aircraft with Novel Effectors (CRANE)[6] programme and sought contributions through a request for information. This is another excellent example of how NATO's members benefit greatly from the experience of the collaboration of the NATO nations.[7]

Conclusion

The path of the AVT task groups described above is just one example of how multinational research is performed in the context of NATO STO. The joint enhancement of the knowledge base among NATO nations leveraged the knowledge transfer into national research programmes as well as into industrial technology and design approaches. The multinational collaboration provided experimental expertise and test capabilities, which any single nation probably could not maintain, and made computational simulation power available to complete a systematic approach in order to achieve a realistic and comprehensive design task by understanding flow physics.

Specifically, the national participants gained knowledge regarding stability and control prediction methods from CFD to Reduced Order Modelling (ROM), and an extended approach integrating experimental and numerical methods. The results of the group initialized and influenced further national research programmes within the participating nations, including the graduate-level education of future scientists and engineers. Finally, an experimental database created in these NATO Task Groups can further be used for CFD validation and as a reference for future design tasks. All of these benefits are the direct result of the commitment of partner nations within NATO working together on leveraged programmes of mutual interest and importance.

Within the network of NATO's AVT community, scientists and engineers from more than seven allied nations and ten organizations shared their experience and technical capabilities in order to improve knowledge, including knowledge of simulation and design tools that are now available and accessible in the field of modern fighter aircraft design and assessment. Organized in more than 12 task groups, NATO's research and development effort has overcome individual technological gaps and thereby strengthened NATO as a multinational collective. The multidisciplinary and multinational approach has proven its success by being applied to the development and in-flight demonstration of innovative flight control effectors in next-generation aircraft, which has reached an outstanding maturity level and greatly benefits the NATO nations.

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Dr.-Ing. Andreas Schütte

started his career as a research scientist at the DLR Institute of Aerodynamics Flow Technology in 1998 in Braunschweig, Germany. His focus areas are vortical flows and fighter aircraft aerodynamics. Throughout the last 15 years, he has been actively involved in the NATO STO community as a researcher, German panel member, and from 2010 to 2013 as the AVT-Panel Executive Officer in Paris, France. In 2007, Dr.-Ing. Schütte worked at the US Air Force Academy, Colorado, US, at the Department of Aeronautics, where he was participating in a research exchange programme. Presently, being a project manager at DLR, he is responsible for one of the major military research programmes dealing with the design, performance assessment, and evaluation of fighter aircraft configurations on behalf of the German MoD.

Prof Dr Russell M. Cummings

is Professor of Aeronautics at the US Air Force Academy, Colorado, US. From 2015–2018 he was the Technical Director at AFOSR's European Office of Aerospace Research & Development in London, UK. Dr Cummings is a graduate of the University of Southern California, where he received his PhD in Aerospace Engineering. He has been actively involved in NATO RTO/STO activities since 2001 and was the co-chair of several task groups, including AVT-251. Dr Cummings has previously worked at Hughes Aircraft Company, NASA Ames Research Center, and California Polytechnic State University, and was a Visiting Senior Scientist at DLR in Braunschweig during 2008. He is a Fellow of the American Institute of Aeronautics and Astronautics and the Royal Aeronautical Society.

Dipl.-Ing. David Klaßen

served as an Officer in the German Air Force from 2004 to 2017, where he started his career by accomplishing studies in Aerospace Engineering. As a Radar Controller and Fighter Allocator, he was serving in the German Air Defence Branch and as a crew member on Aircraft of the NATO AWACS fleet in Geilenkirchen, Germany. During his time as an Officer, Mr Klassen was involved in several multinational large-scale exercises as well as operations, such as ISAF and Counter Daesh. After leaving the Air Force, he worked three years as a consultant and authorized officer for the management consultancy branch of KPMG Germany. Since October 2020, he is serving NATO STO as the AVT-Panel Executive Officer in Paris, France.

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Transitioning NATO to an All-Domain Mindset

By Captain Daniel Cochran, US N, JAPCC
By Colonel Matthew Willis, US AF, JAPCC

Refocus on Joint and Combined

Joint All-Domain Operations (JADO) is a concept with the ambition of maximizing the effectiveness of all declared NATO forces through broadly focusing on two critical interoperability areas: obstacles between services and across the nations. The overarching goal of JADO is to progress from coordinated joint actions (today's capability) to synchronized all-domain operations. Considering that there are 30 NATO member countries, the Alliance has somewhere around 90 separate national services, each having their own identity, culture, and capabilities. Any effort that receives input from more than one of these 90 different services while making headway on improving interoperability across the Alliance should be considered. Historically, there has been a long list of warfighting philosophies designed to achieve progress in employing service-specific forces in a cohesive manner across two or more domains. Previous examples of efforts to expand 'joint warfare' concepts include 'Air-Land Battle'[1], 'Air-Sea Battle'[2], 'Effects Based Approach to Operations (EBAO)'[3], Net Centric Warfare, and most recently both 'Air Land Integration (ALI)' and 'Multi-Domain Operations (MDO)'. MDO has established a foothold within the minds of NATO's military thinkers, because it begins to examine the enormous potential of a truly integrated future joint force, able to simultaneously tap into capabilities across the entire spectrum of current and emerging systems available from military services. MDO has been described as 'joint warfare on steroids', making a reference to the number and speed of decision-making as compared to traditional joint warfare.

If embraced by joint leaders across NATO nations, MDO-focused efforts may create more interoperability throughout the approximate 90 services. There are, however, a few foundational issues with this joint effort that can be easily rectified. First, because essentially most services already operate across multiple domains, senior leaders who don't believe MDO is a new idea or required for joint growth have been heard to essentially say, 'Yes, I love multi-domain operations. We have been doing that in the Navy (or Marines, Army, Air Force) for decades and find it to be very effective.' Second, although the approach of categorizing warfare actions into domains may have been historically appropriate, considering the entanglement of systems and interconnected capabilities spanning the domains in today's state-of-the-art militaries, it can be argued that the traditional rigid structure of services based on their principle operating domain may not be very useful in many future scenarios. It is likely that the victor will emerge as the force able to manoeuvre easily in and through all domains in an efficient and synchronized manner at a speed which the opponent cannot match. Finally, since the vast majority of global militaries plan for and rely on their ability to conduct operations in a coalition environment, as is certainly the case for NATO-aligned nations, operating combined should be at the centre of the effort. In support of these tenets for the future of NATO operations, the 'NATO JADO' project has been introduced by the Joint Air Power Competence Centre (JAPCC). The current working definition for this term is:

NATO Joint All-Domain Operations

Actions taken by the joint forces of two or more NATO nations, comprized of all available domains, integrated in planning and synchronized in execution, at a pace sufficient to effectively accomplish the mission.

As previously discussed and implied in the title, the focus of this effort is joint and combined. Another joint focused effort, led by the United States (US) called Joint All-Domain Command and Control (JADC2) has recently decided to modify their title by adding 'Combined' to the front, updating the effort to CJADC2.[4] Considering the way each service (and even platforms within each service) has built their data architecture, it may take a decade to achieve seamless Command and Control (C2) of only US assets, however the change in name is important. Adding 'combined', even if only initially in small groups of nations, helps keep the ultimate goal in sight as small advances in all-domain operations are attained.

Deterrence has been effective thus far for the Alliance. In the 72 years since the establishment of NATO, the Alliance has not faced a true existential challenge. There have been numerous cases of 'coalitions of the willing' engaging in combined campaigns which have identified many lessons. Building alliances has proven to be critical to successfully responding to a crisis in that it confers legitimacy on the effort while also increasing available forces and capabilities, reducing each nation's individual burden. However, responding multilaterally creates challenges across the entire spectrum of the effort, from planning through execution and evaluation. Common issues include: maintaining proper alignment of the coalition and national priorities, asymmetries in the allocated forces in terms of technology and capabilities, operating with shared (or at least interoperable) Tactics, Techniques, and Procedures (TTPs), ironing out national caveats, determining a sound structure for C2, managing language barriers, and religious and cultural differences. Compounding the challenge, these obstacles can be even more difficult to quickly overcome when the coalition is required to coalesce and respond in a rapid manner due to an emerging crisis. NATO leaders should ensure that preparation for future operations is strongly influenced by this reality.


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International Security Assistance Force (ISAF) was a NATO-led military-mission in Afghanistan from 2001 until 2014 and was comprised of 28 NATO Allies and 22 NATO partners.

Training All-Domain Leaders

To develop operational leaders who are truly able to command with an all-domain perspective, joint training and education should start early in their careers. A leader who has spent the majority of their military employment tackling problems from a component-specific view of assets may find adapting their thinking to an all-domain mindset very challenging. In order to eliminate these biases in problem-solving, future JADO commanders might not be affiliated with a specific service at all. Even without knowing with much granularity what NATO JADO will look like, it is clear focus should be given to improve the 'joint experience/expertise' of leaders. Building these leaders at a young age, they will be better prepared to lead as portions of the NATO JADO concept begin to become operational reality. Just as essential to the conduct of operations in a future crisis will be the fundamental understanding of the multi-domain nature of NATO's future forces. This will require the Alliance to educate, train and exercise forces in scenarios which promote all-domain understanding across the force and challenge traditional barriers to interoperability. The complexities of all-domain warfare will drive future leaders to have to increasingly rely on field commanders and operators to execute a variety of 'mission-type' orders while adapting to battlefield conditions as the conflict progresses and non-domain specific challenges and opportunities present themselves.

All-Domain Operational Execution

How can NATO continue to pivot towards considering effects across the domains? A step in the right direction might be to fortify the Joint Force Commands (JFCs) and their role in the planning and execution of large, joint operations. Over the past eight years, the JAPCC has been involved in the major NATO joint exercises and has contributed to the evolution of threat scenarios and dramatically improved the realism and complex nature of multi-domain warfare. Leaders and staffs across NATO have come to accept much more challenging situations along with embracing lessons identified through failure. These are very important advances along the path to improving and modernizing the mindset of NATO's leaders when it comes to joint operations. Exercise Control is providing the training audience multi-domain warfare problems, and leaders are embracing this challenge.

However, progress in this evolution of thinking has been hampered by the use of historical component-specific problem-solving. An example of where this mindset needs to mature, is to consider the problem of trying to apply effects in an area that is highly contested, at least to some degree, in all-domains (sometimes referred to as Anti-Access/Area Denial or [A2/AD]). The adversary must employ highly capable systems across multiple domains to create this environment, and as such, it generally requires allied effects across all-domains to effectively gain access. However, JFCs have generally kept a more traditional approach, handing over the lead in this truly joint problem to a single component command. Component commands are experts in their component capabilities and have direct access to only their assets. Without the resident cross-domain knowledge and the large number of liaisons located at the JFC, component commands may not have the requisite insight into the capabilities and capacity of other components operating in the area. Although the supported commander is able to request support from the supporting components, there exists a tendency to use the assets under their control first, even if they are not the most effective for the specific mission. One step to begin training to an all-domain fight would be to favour the joint commander keeping primary responsibility for tasks that require a wide range of joint assets to achieve success.

Perhaps the solution involves a more tailorable command structure that considers the primary variables for a specific conflict. Depending on the conflict scenario (scale and complexity), the actual forces which have been allocated, and the level of joint training and experience the joint and component commanders (and their staffs) possess, asset apportionment and allocation could reside at various levels within the command structure. This more flexible command construct will likely challenge current views of supported and supporting relationships, and leaders should ensure the resulting command structure retains clear unity of command while maintaining focus on the strategic goals.

Synchronizing Joint Capabilities

NATO continues to develop joint capabilities, but still suffers from only being able to achieve 'coordinated

Aegis Ballistic Missile Defense (Aegis BMD), designed for use in surface ships, have been modified for land-based and stationed at ground locations to bolster Europe's BMD capabilities.

joint actions' and not 'synchronized all-domain operations'. While this is partially a function of the limits of the current C2 systems and structures, there is much more evolution possible in the 'mindset and leadership' areas. The JAPCC's new NATO JADO study will evaluate process improvements for air operations to address the limitations in C2, leadership models, joint force training and information sharing. As technologies continue to improve and are more widely fielded across the Alliance, NATO leadership and training models must be poised to take advantage of these warfighting advances. With finite resources, generally characterized as stagnant for the majority of NATO nations, it is vitally important that decision makers maintain strong connection to the needs of their troops and concentrate their efforts on achievable projects that directly get after the most impactful solutions. The wide capability disparities between the 30 NATO nations are a challenge to the Alliance's interoperability, but not an insurmountable barrier on the path toward NATO JADO. The key to mitigating the variations in national resources and military capabilities will be JADO training and education which should begin immediately. In addition, the impact of disparities in JADO competencies across the nations going forward can be lessened by a robust education and exercise regimen to test proposed leadership models and develop solutions to training deficiencies and improve decision speed.

Lessons Identified

The goal of combined, all-domain operations is a lofty one, especially when applying it to a large, NATO-led effort. However, through a plethora of nationally-directed efforts and exercises, lessons have already emerged that should be collectively incorporated into the Alliance to continue progression. One lesson theme identified has been the requirement to incorporate joint and partner considerations early in the development of national systems. Additionally, NATO needs to clearly define standards to avoid future interoperability issues while antiquated systems should be upgraded or replaced, if they cannot meet the standards. The majority of resources should be given to efforts that have matured to a state where tangible results can be produced. For example, there has been ample discussion about what future joint doctrine may look like in terms of who approves actions and who has control authority over assets. However, NATO's current joint doctrine is able to broadly support JADO, and until more tests and exercises are conducted, efforts may be better served on known JADO deficiencies such as the establishment of a robust C2 system, able to link sensors to shooters across organizations. Emphasis on development of advanced C2 should be prioritized now, instead of waiting for updates to the doctrinal hierarchy. Furthermore, joint exercises have unequivocally concluded that JADO requires a high level of decentralized execution to be

efficient. Considering the trend in many militaries over the last few decades which could be characterized as moving towards more centralized control, the question remains if current TTPs are able to support an expansion of decentralization or indicate the need for a modification. Additionally, NATO's existing standardization protocols, each nation's budget realities and support to national industries, and the uneven distribution of advanced technologies will continue to challenge interoperability efforts and promote the lop-sided allocation of burdens across the Alliance. To fully mitigate these factors, it will be necessary to reimagine the supported and supporting relationships in joint warfare settings.

Conclusion

The ability of NATO forces to be seamlessly interoperable, complementary, and harmonized will be required to prevail against potential future peer adversaries while minimizing allied losses. Considering the rapid advance of technology and capabilities worldwide, their uneven distribution, along with the relatively recent expansion of warfighting domains (space and cyberspace), the requirement for NATO to learn how to operate synergistically across all-domains is clear. If, in this process, it is concluded that it is too difficult to combine 90 disparate organizations to fight cohesively, consider the situation where potential adversaries outpace NATO in the effort to evolve to an all-domain force. This is likely the most demanding military problem allied-nations and NATO will face, and all must act collectively and urgently to meet the challenge.

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Big Data in ISR

Big Opportunity for Data Analysis Challenges

By Major Giuseppe Valentino, IT AF, JAPCC

Introduction

Over the past few decades, the use of data and information has been exponentially increasing. While data collection is an expected and thus normalized facet of life, reinforced by the many bureaucratic protocols people adhere to in order to live, work and travel, it is profoundly different in military operations, where data processing is the key to achieving effective results. The overwhelming volume of data, combined with its complexity, causes any necessary decision-making to be a long, drawn out and cyclical process which impacts ongoing operations. Indeed, the human brain lacks the capacity to manage information in a short-time frame and find the appropriate response quickly. For these reasons, the Big Data issue, related to new technologies and modern multi-domain operations, has been a critical focus area in recent NATO debates. Current theories are unable to define the concept of Big Data coherently or consistently, mainly due to the complexity and ambiguity of the idea[1]. The aim of this article is to cast light on Big Data and its potential purposes in the Intelligence Surveillance Reconnaissance (ISR) in terms of the data management approach.

This article reflects a portion of a wider JAPCC study on the same subject. Readers are encouraged to look at the 'Big Data Management in ISR and New Technology Trends' white paper for a more in-depth understanding.

Big Data Statement

The term Big Data[2] can be defined as multiple sets composed of many bits of data, analyzed or not, and interrelated by tools based on dedicated algorithms for information exploitation. It might not involve a new technology or a new database, but 'it is a relationship between data and the organizational, procedural and cultural factors that make up the enterprise. It is primarily about the ways in which data is managed.'[3] According to the Gartner definition, 'Big Data is high volume, high velocity and/or high variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation.'[4] The statement quoted in this article most represents the current view in supporting this explanation.

Big Data is comprised of collected datasets and information that are characterized by complexity and are not immediately useful for exploitation. The simple and disaggregated dataset may not support the decision-making process at any level. Overall, the use of Big Data could bring an operational advantage, but only if the information can be turned into readable data in a time-sensitive manner to deliver indications and warnings for threat analysis.

The scientific world defines Big Data by five leading attributes:[5]

Volume: Currently available data reaches into the terabytes and even petabytes. The 'big' represents millions and billions of information bits stored in different databases. To quantify the exact volume of data is difficult to do at any one moment.

Velocity: Refers to the data exchanged among the interconnected systems within a specific measure of time. In daily life, organizations constantly and continuously collect new data, in real-time, from myriad sources, and exchange information among organizations very rapidly.

Variety: Big Data is comprised of text, images, videos, and other information continuously created, collected, and shared.

Veracity: Accuracy is not always present in large data or datasets. Acquiring a huge variety of data can reduce the level of accuracy. Accuracy is a criterion to select and clean data to determine what portions should be processed to obtain useful information.

Value: The term 'value' is often used interchangeably and without precision. It might represent additional information that it is achievable only by combining a huge amount of data by tools[6]. Big Data is as valuable as its utilization in the generation of actionable information. There is no disagreement that data holds the key to actionable insights to validated information; however, the post-modern organization needs to progress quickly to be able to analyze data automatically. Moreover, it is essential to understand the patterns within the data, and to provide solutions in visual[7] and readable information to add value.

Overall, Big Data could be considered a federated database[8] with the following features:

- Structured data;
- Unstructured data;
- Semi-structured data.

The challenge is to enable automatic data processing and data interconnection among information streams for advanced applications. The correct use of Big Data, through employing different information or databases sourced from all domains, may be essential to reach the desired information dominance to support military operations.

The 'world of data' provides the possibility of having a copious amount of differing information simultaneously. The current dilemma is how to obtain usable intelligence to support Commander's Critical Information Requirements (CCIR)[9] and related priorities inside the complexity of the decision-making process. Recently, many nations have improved their capability to gather information due to the possibility of interconnecting multiple databases. Despite the increasing capabilities of available systems, a critical point remains as to the ways in which to manage the countless amounts of data acquired. In other words, complex organizations, like NATO for example, should

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be able to establish a common and standard criterion to use data and related analysis. It may be reasonable to follow the systematic approach by providing for common:

- Data strategies;
- Management of data systems;
- Policies for data storage;
- Validating processes and algorithms.

Management of priorities became the first element inside the Big Data analysis that was essential in supporting operational data users.

Another important priority is the data storage, considering that much of the information about a potential adversary is already present in the databases. Nevertheless, information should be stored according to a useful structure, which guarantees and implements basic intelligence practices. Furthermore, the most critical aspect for NATO is to have sharable ISR databases that could support information systems and warnings.[10] The methodology and data matching should be a pre-defined process to validate the analysis.

Using Big Data

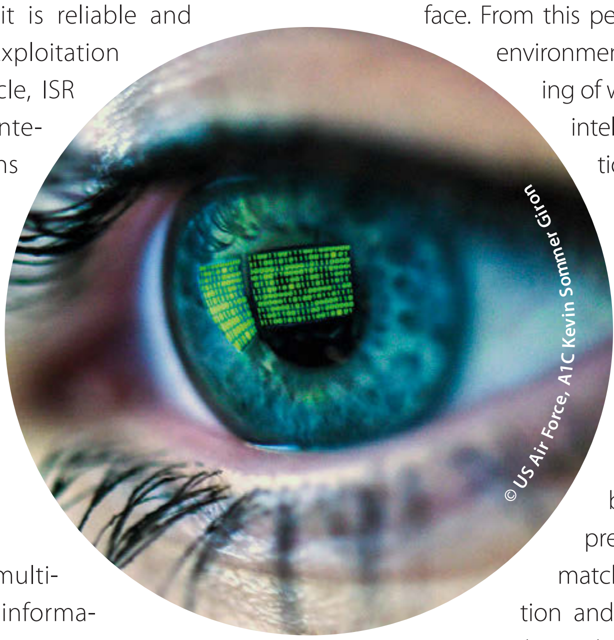
Recently, NATO acquired its first owned unmanned ISR system[11], Global Hawk, which will permit the gathering of videos and data worldwide. In fact, ISR can count on support from Air Power and Space through images and other data collection that is essential in obtaining current intelligence as well as maintaining information superiority. Moreover, the NATO information system is integrated by other data sources and national data contributions based on a federated architecture. These outstanding volumes of data highlight the opportunity to identify a new architecture of technology to enhance the use of Big Data to optimize the Alliance's capabilities in intelligence management.

Recently, researchers displayed an increased interest in new technologies for Big Data, which provides an important opportunity to apply and optimize data fusion process for military purposes. At the same time, it is reasonable to note the data analysis in which the key factors are there to protect allied assets and troops. The use of emerging technologies and tools represents a turning point in transforming intelligence analysis and command and control synchronization.

As argued by Air Chief Marshal, Sir Stuart Peach, '[Big Data] holds great potential for the Defence and Security sector but [the Ministry of Defence] must not fall into the trap of procuring only bespoke software solutions if it is to exploit the technology in a timely manner.'[12] The challenge in ISR is to apply Big Data with a clear management methodology for reducing the time taken to disseminate information and mitigate errors in assessments due to human factors.

Improving the Processing Exploitation Dissemination Cycle to Support Commander's Decisions

ISR issues in NATO are well known and have been highlighted in recent operations. The limitations due to data exploitation in ISR manifested during the crisis in Ukraine where NATO was surprised by a Russian so-called 'snap exercise'. Information was collected, but not immediately available, for actionable intelligence to support rapid decision-making on how to exploit the information gathered on preventing Russia actions in Eastern Ukraine. The key to success for the future of ISR is to synchronize operations and intelligence by continuous exploitation of analyzed data, ensuring it is reliable and validated. In the Processing, Exploitation and Dissemination (PED) cycle, ISR should guarantee the full integration of operational domains and set up a new mindset based on multi-domain data collection. In other words, Big Data brings a new perspective inside PED, in terms of timely, validated and actionable 'readable data' that need to be defined.



Currently, NATO counts on multiple databases and various information datasets, managed by various nations; the critical link in this system is the missing interconnection of those databases between storage locations as well as a lack of optimized data processing in the overall exploitation process. The old concept of PED[13] should be revisited from a new perspective, where the time and reliability of gathered information and its reliability to guarantee a seamless transition and translation into the decision-making cycle is assessed. One of the important things to consider is the role of networking among systems based on cloud computing resources, capable of collecting data and processing information close to the relevant 'event'[14].

Task Collect Process Exploit and Disseminate (TCPED) at the Tactical Level

At an operational and strategic level, data could be analyzed, correlated with other sources and evaluated accurately, while the tactical level manages the huge amount of incoming information, which would translate to data being made available in a timely manner in current operations to support real-time and near-real time decision making. Within the current intelligence management structure, in which the key to success is the time taken to gain awareness of the ongoing situation, Big Data's strategy plays an essential role in generating actionable intelligence. The high response time required to detect and collect data before processing and dissemination, is a real challenge that ISR needs to face. From this perspective, Big Data in the ISR environment will facilitate an understanding of what is valuable from the basic intelligence and provide information to extrapolate these findings into the current situation. This ensures exploitation of data reliably and in an automatic manner.

To illustrate this point, the use of tools for Moving Target Identification may have been imagined, in which a pre-defined set of data could match a variety of target information and other related sources referenced to obtain usable intelligence and deliver assessments in the shortest time frame possible. The 'Unified Vision' exercises, based on federated data exploitation architecture, underlined the notion that TCPED[15] is a critical issue due to the lack of alignment and standardization between datasets. It is presumed that in information analysis, 88 % of 'usable data is being left untouched'[16] due to a multitude of characteristics such as data complexity, human capacity, storage issues and connectivity. There is no doubt that emerging technologies (e.g. Machine Learning, AI, etc.) will continue to progress in the future together with advanced tools for optimizing intelligence exploitation, but Big Data strategy is the first step in sustaining intelligence applications and resolving the information dilemma for the decision-making process.

Recommendations

In conclusion, the following recommendations should be considered in order to apply the Big Data concept and put in place the required methodologies to orientate it to military use and exploitation:

- Applying standard concepts for linking databases from the Intelligence disciplines;
- Interconnecting structured and unstructured databases by software applications and algorithms;
- Selecting information more easily, quickly and accurately;
- Structuring tools and queries according to Intelligence Requirements Management (IRM);
- Data matching and fusion by analysis;
- Enhancing information from text, documents, raw data, crypto information and converting them into actionable intelligence;
- Extracting data, building models and delivering intelligence solutions;
- Avoiding arbitrary systems of data classification;
- Reducing the complexity of information;
- Optimizing multiple-source data fusion.

It is important to define the correct algorithm based on a clear Big Data strategy for ISR purposes. Big Data is synonymous with 'big opportunity'. The traditional ISR PED system has proven itself to become overwhelmed by the sheer volume of data and it is necessary to build alternative approaches in terms of analysis, data storage and information sharing. The first step is to identify NATO's Big Data strategy through a multi-disciplinary and multi-domain vision. The overall aim is to reduce data complexity and consistently support the decision-making process at all levels of the command structure.

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started his career in 1992 joining the Italian Air Force NCO School in Caserta. During his service worked in E.W. group as an Intelligence Analyst and had two tours to Sarajevo (Bosnia-Herzegovina) and was responsible for analysis and production in the Deployed Intelligence Cell.

In 2005, he was engaged as a Force Protection platoon leader in Kosovo as well as supporting other key NATO operations. From 2010 to 2019 he was Section Head of COSMO-SkyMed operations in Italian Defence User Ground Segment (IDUGS). Major Valentino holds an MA with honours, in Political Science Sapienza University of Rome and an MA (level II) in Peacekeeping and Security Studies University Roma Tre, and currently serves as an ISR Subject Matter Expert at the JAPCC.

The Multinational Multi-Role Tanker Transport Fleet Programme

Relevant for NATO-EU Military Air Transport?

By Lieutenant Colonel Juan Manuel Chomón Pérez, SP AF

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'Competition has been shown to be useful up to a certain point and no further, but cooperation, which is the thing we must strive for today, begins where competition leaves off.'[1]
Franklin D. Roosevelt

Introduction

During the Cold War, strategic Air Transport (AT) did not play such an important role among the priorities of European countries because of its static geography. With the fall of the Berlin Wall and after the progressive development of the EU, the AT capabilities of European countries were put to the test in their participation in missions in Afghanistan under the NATO flag after the attacks of 9/11 in 2001.

The shortcomings of AT in Europe were obvious following 9/11, as the Member States (MS) of the EU had to resort to initiatives as the Strategic Airlift International Solution (SALIS) or the Strategic Airlift Capability (SAC).

Further, and more recently, when referring to Air-to-Air Refuelling (AAR)[2], these shortcomings were seen in the allied air operations in Kosovo, Libya and Mali, in which some members of the EU had to call upon and rely again on US refuelling aircraft.

Simply stated, the EU identified major gaps, over a number of deployments, among the capabilities required to successfully carry out those military operations to include strategic AAR, AT and Aeromedical Evacuations (AE).

'Less than 3 % of European troops (40,000) are deployed due to shortcomings in the field of interoperability and a shortage of equipment. This figure contrasts with the 200,000 US troops deployed abroad.'[3]

Traditionally, strategic AT capacity to carry out EU missions has always been based on the contributions of EU Member States, revealing gaps and delays in the process of generating forces to carry out missions under either their own EU flag or when integrated into NATO missions.

Until recently, EU MS acquired their aircraft or developed their capabilities based on national requirements. The acquisition of the A400M and the A330 MRTT are an intermediate step, signifying an advance towards the alignment of national, EU and NATO objectives.

In the current context of economic crisis, the concepts of pooling, sharing and smart defence, through air cooperation models, allow some of the nations to maintain a set of capabilities or to develop new ones which they could not do on their own, based on their resources.

Considering that less than 60 % of European AAR end-users (receiver countries) operate their own AAR strategic aircraft, the Multinational Multi-Role Tanker Transport Fleet (MMF) represents an innovative and cost-effective solution, in order to help its members meet their requirements, not only for AAR but also for AT and AE capabilities, and join the EU or NATO missions.

The Programme

The MMF is an international NATO air cooperation programme based on the acquisition, management, and operation of a fleet of Airbus 330-200 Multi-Role Tanker Transport (MRTT) aircraft.

The programme was launched in 2016 with the signing of the Memorandum of Understanding (MOU) between the Netherlands and Luxembourg. Other European States joined in the following years, including Belgium, Germany, Norway, and the Czech Republic.[4]

Its creation responds to the need to renew or to cover the lack of strategic airlift capabilities existing at the European level, in particular the capabilities[5] of AAR, AE and AT of passengers and material at an inter-theatre level.

During the initial phase, nine A330-200 MRTT aircraft, with the possibility of expansion to eleven, were acquired by the 'Organisation Conjointe de Coopération en matière d'Armement' (OCCAR), on behalf of NATO and under the auspicious of the NATO Support and Procurement Agency (NSPA).

The operation of the nine MRTT aircraft is carried out from the Multinational MRTT Unit (MMU) from two airbases. The Main Operating Base (MOB) in Eindhoven, The Netherlands, will operate five aircraft. Four aircraft will operate from the second airbase, which is a Forward Operating Base+ (FOB+), located in Cologne, Germany.

The projects related to the infrastructure of the MOB and FOB+ have been completed. Three crews received initial training at Airbus facilities in Seville and continue to train while operating from Eindhoven.[6]

The programme members operate the aircraft, but these are owned by NATO. The economic participation of each country resulted in a proportional amount of flight hours, which according to the current MOU, is 9,900 annual flight hours in total. The only contribution of the member nations not covered through economic payment is the apportionment of personnel from each nation to the MMU.

One example of the great benefit of the MMF is the participation of the Czech Republic. With a minor economic participation, equivalent to 100 flight hours, it has access to the full spectrum of capabilities of the MRTT fleet.

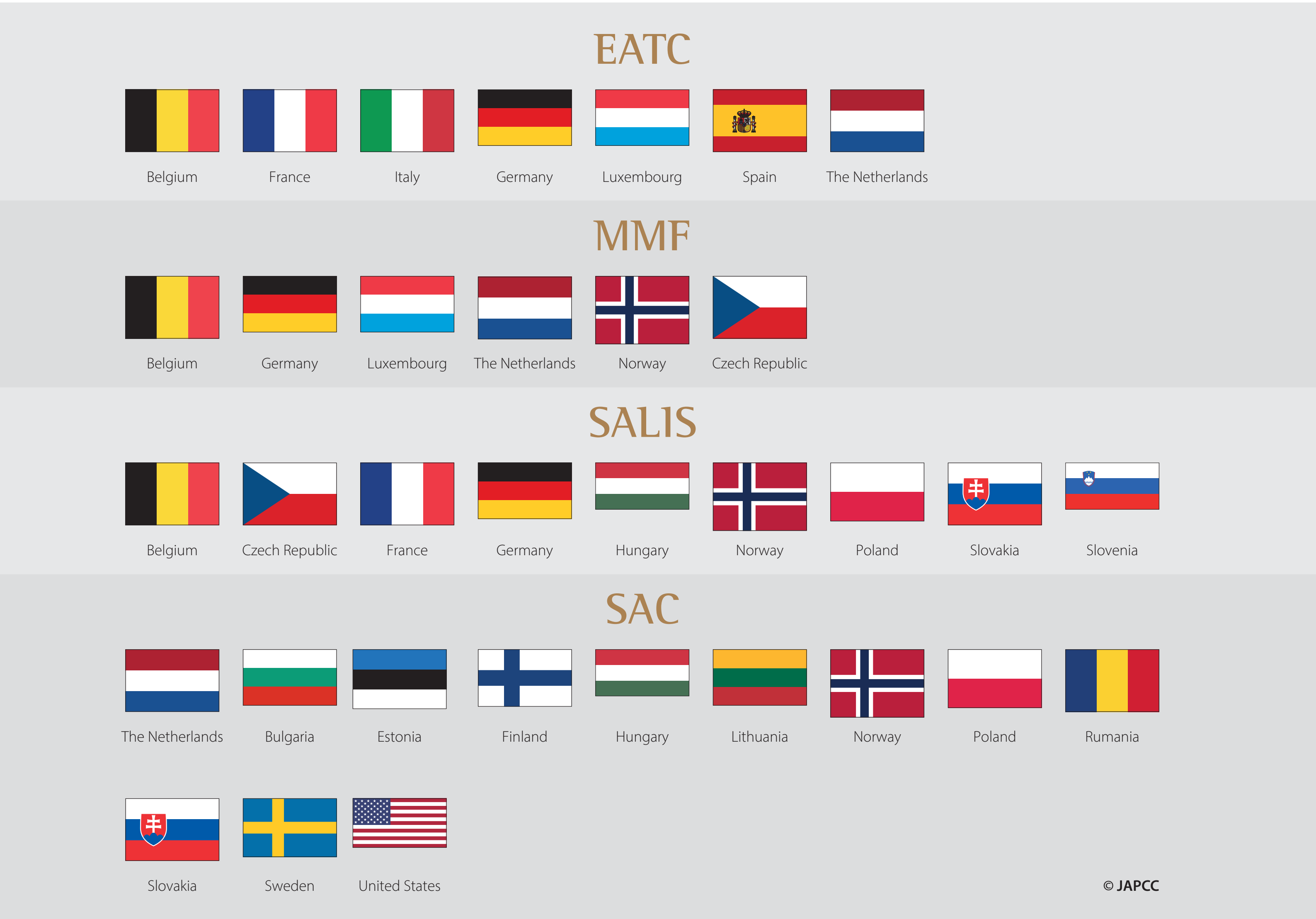
Another huge benefit of the MMF's structure is that it allows any member nation to sell part of their flight hours to countries outside of the programme. This fact allows not only 'burden sharing' of this type of strategic support system, but also provides access to its capabilities to all NATO and EU countries, with greater flexibility.

Having already completed the first training missions, MMU's Initial Operational Capability (IOC) is expected before the end of 2021 and Final Operational Capability (FOC) in 2024.

The MMF Among the European Airlift Cooperation Models

As an international military cooperation programme, the roots of the MMF lie in the concepts of pooling, sharing and smart defence. There are three similar cooperation programmes based in Europe with ownership or authority over military airlift assets:

- the European Air Transport Command (EATC);
- the Strategic Airlift International Solution (SALIS);
- the Strategic Airlift Capability (SAC).



The EATC is a multinational Operational Command that exercises Operational Control over a large part of the military transport aircraft of its seven participating nations[7], in order to optimize their use as they are considered a critical means. This fleet represents more than 70 % of the EU airlift assets, with the Airbus 400M constituting the backbone of the fleet. The aircraft are always operated by the air units of the participating nations. These air units are referred to as executing agencies within the EATC. In this sense, MMU operates under the umbrella of the EATC as another executing agency, with the peculiarity that is a multinational unit in itself.

The MMU main contribution towards the EATC is its strategic component, which cannot be covered with the A400M alone, especially in the field of AAR.

On a daily basis, the EATC, which is co-located in Eindhoven, will provide the planning, tasking, and mission control of this MRTT fleet.[8] To do this, in due time, the EATC Commander will receive the Operational Control of the MRTT aircraft, which is currently being exercised by the MMU Commander.

Same as the EATC participating nations, the MMU Commander can always revoke the transfer of authority of its aircraft given to the EATC.

SALIS was established in 2004 as a multinational consortium. Its MOU was signed in 2004 considering the 'Berlin Plus' Security Agreements between NATO and the EU. In this agreement, NATO was supporting the planning and execution of EU-led Crisis Management Operations, allowing the EU to draw on some of NATO's military assets.

Currently, the SALIS programme is managed by the NSPA on behalf of nine NATO European Allies.[9] The contract with the civil company Antonov Logistic SALIS (ALS) allows access within a few days to five Antonov An-124-100 type aircraft and secondary to AN-22, AN-225 and IL-76, subject to availability. The consortium countries have committed to use 1,600 flight hours per year.

Until 2016, the 'I' of the SALIS acronym stood for 'Interim' instead of 'International'. This term 'Interim' referred to the fact that this initiative was designed to fill the NATO-EU transport gaps[10] until new A400M aircraft or other airlift strategic options, as the MRTT, could be deployed around 2025.

The main advantage of this programme is the huge cargo transport capacity, including a great variety of oversized material. An AN-124-100 can carry up to 122 tons of cargo with a range of 5,250 km. In comparison the MRTT can only carry up to 40 tons and is not prepared for oversized material. MRTT having neither a cargo ramp nor an adequately prepared cargo bay will never replace the Antonovs of the SALIS programme.

The SAC programme was created in 2008 and presents more similarities with the MMF. When creating the MMF programme, The Netherlands and Luxembourg followed similar patterns to the SAC NATO air cooperation model.[11]

In both programmes, the NSPA manages and coordinates on behalf of the nations and provides global logistics support to the fleet throughout the whole life cycle of the systems. This includes maintenance services, material management, infrastructure, Information Communications and Technology (ICT) and general support.

When comparing the two NATO programmes grounded in Europe, there are two main differences. The first is that the United States (US) is the leading nation of the SAC, while The Netherlands is leading the all-European MMU. The second difference consists of the size of the fleet and the capabilities provided by their respective aircraft.

The strength of the SAC programme lies in the 72.6 tons cargo transport capability of its three C-17 'Globemaster'. The C-17 is able to transport palletized oversized cargo, as well as land vehicles or helicopters, and land on small unpaved runways or deliver by airdrop. The C-17 can also be specially configured with airline-style seating pallets to transport up to 188 troops,

Comparatively, the MMFs A330 MRTT passenger transport capacity and comfort are higher with up to 267 seats in its basic configuration, with simultaneously

40 tons of load in the cargo lower deck compartment. But the aircraft is not prepared for loading oversized material nor landing on unpaved runways.

In fact, it is the MRTT's AAR capability, with its state-of-the-art Boom and Hose and Drogue systems, which contributes to the programme's main strategic relevance.[12] The aircraft's 111-ton (245,000 lb) fuel capacity enables the MRTT to perform AAR missions without any additional fuel tanks and without the need for reconfiguration to accommodate probe or receptacle receivers, making it compatible with the AT and AE missions, highlighting its true Multi-Role capability. This interesting feature could be used concurrently during the deployment, redeployment and sustainment of many international EU or NATO missions, as well as combining AAR training with other AT missions. The Operational Control of the MRTT aircraft by the EATC is a key advantage to manage the required multinational planning and interoperability.

Contrasted to the US Tanker fleet, with more than 400 KC135s and 179 KC-46A 'Pegasus' foreseen for 2027, the MMFs fleet of MRTTs may seem like a small collaborative regional cluster.

However, the entire strategic AAR fleet of the 27 MS of the EU, before the development of the MMF initiative, did not reach 25 aircraft and was concentrated in five countries (France, Germany, Italy, The Netherlands and Spain). Therefore, the MMF, adding up to eleven new aircraft represents a major quantitative and qualitative leap forward.

MMF Capabilities Available to Partner Countries

While the centre of gravity of US interests moves towards the Pacific region, that of the EU oscillates between the North Africa-Sahel area and the containment of Russian territorial ambitions. Consequently, the US shift of focus necessitates that Europe strengthen its position as an international defence partner and take a relevant role in the management of its own borders.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The EU is progressively becoming a stronger global actor that reinforces the projection of its Common Security and Defence Policy beyond its borders.[13] As a result, in the last decade, the MS of the EU have repeatedly projected their power by using airlift assets, not only under NATO but also under the EU flag. In fact it was the European Defence Agency (EDA) of the EU, who picked up the European deficiency of AT capabilities, and promoted the initiative of the MMF which still it supports today.[14]

The MMF possesses the AT capabilities that, once available to the EU, could increase its autonomy and its reaction capacity, thus favouring the EU strategic partnership with NATO. The operational MMF will help the EU to deploy its Battle Groups, the Eurocorps, the troops and capabilities associated with the new EUFOR Crisis Response Force (CROC) and support NATO deployment of the NATO Reaction Forces (NRF) and Very High Readiness Joint Task Force (VJTF).

As a result, it is expected that, in the near future, an interaction among the MMF Programme and EU organizations as the Military Planning and Conduct Capability (MPCC) or the European Union Military Staff (EUMS) will materialize. This interaction is already visible through the new agreement signed between the MPCC and the EATC concerning the cooperation in the area of AE, which also impact on the MMU.[15]

Conclusion and Way Ahead

The AT capabilities of the MMF should be considered a key factor (key enabler) to enhance the missions of European allied states within the EU and NATO framework. They will allow third-party European nations that do not have their own means of strategic AT and AAR capability to mobilize and deploy their troops and fighter aircraft in support of NATO and EU missions.

Furthermore, MMF enables the European states to partially reduce the reliance upon US strategic assets.

The strong point of the strategic capabilities of the MRTT are AAR, AE and passenger transport, adding the Multi-Role capability itself without the need to reconfigure the aircraft. This feature can be optimized thanks to the cooperation between the EATC and the MMU.

The cargo transport of oversized material is a capability shortfall of the programme. Strategic cargo transport missions will continue to depend on SALIS, SAC, civilian assets and/or the US Air Force.

The way ahead for the MMF Programme envisions a tight cooperation between the MMU and other MRTT operators such as France, or maybe Spain, in the future. The cooperation with France has recently started in the fields of spare parts acquisitions, maintenance, training, and use of standard operating procedures.

However, it would be desirable, and it is maybe foreseeable that more countries would join the MMF programme. Sweden and Finland could become members promoting the creation of a new northern European FOB that would eventually cooperate in the Baltic Air Policing (BAP) Mission. ●

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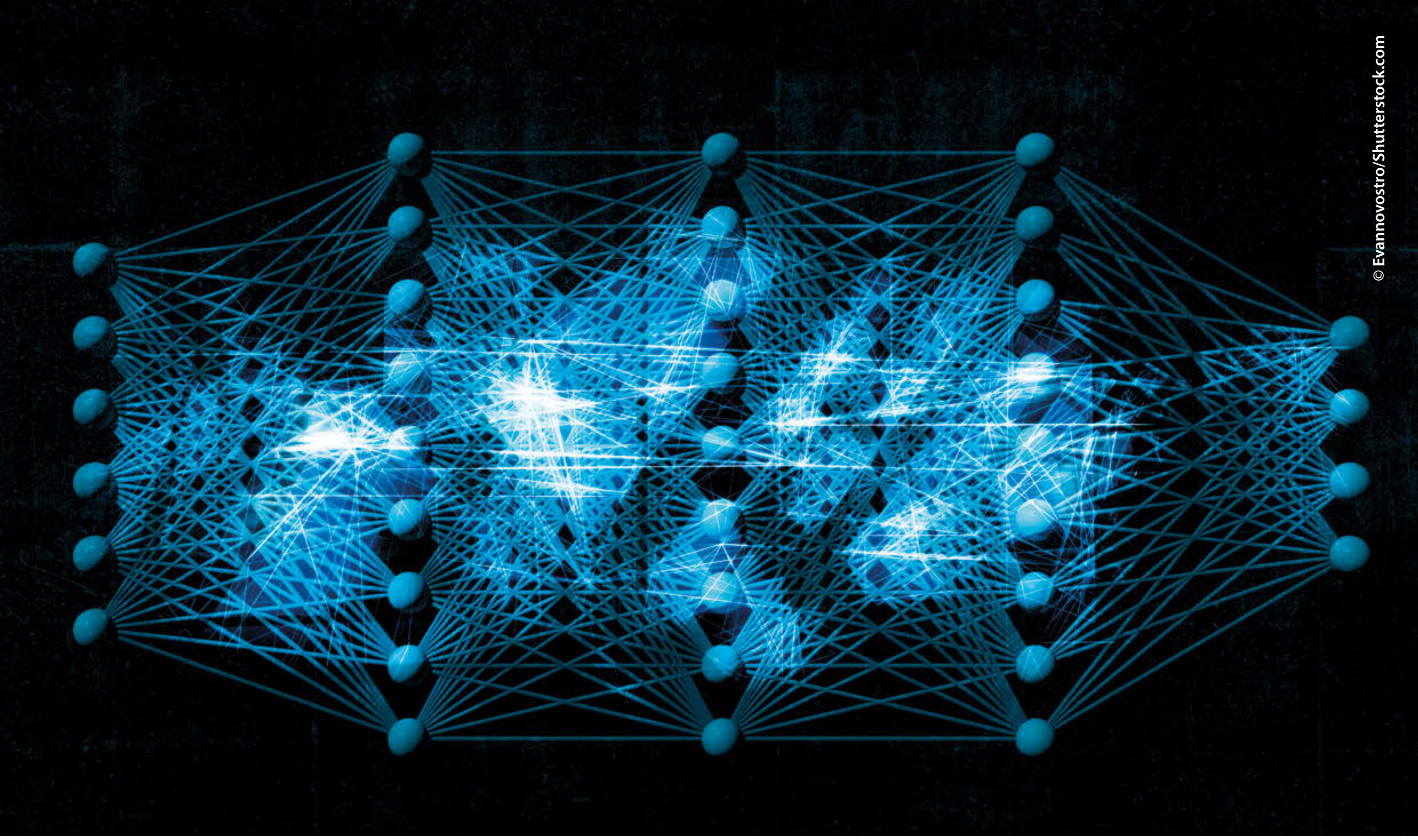
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Bots Taking Over

The New-Breed Decision Makers

By Major Mehmet Bayram, PhD, TU AF, JAPCC

Introduction

Decision-making problems, one of the main research areas of management science, have been studied in a highly-interdisciplinary manner by the contributions of the scientists and engineers from various research fields. Advances in Artificial Intelligence (AI) and utilization of AI systems in the decision-making realm led to a new era, where human decision authority is increasingly being delegated to machines. More than two decades ago, game and interaction-science researchers, as well as chess fans, were thrilled by the defeat of the chess grandmaster Garry Kasparov by Deep Blue[1]. Since the striking newsflash, not only the computing power of machines, but also decision models and programming algorithms have drastically improved. By the time the chess match was carried out, Deep Blue could evaluate 200 million possible moves and predict 20 steps ahead in every single move[2]. Modern intelligent machine capabilities reach far beyond that, becoming a prevalent part of popular science discussions of professionals, including the military. However, the conceptual framework of AI and its subsidiaries are not commonly well-perceived.

NATO's innovation team[3] notes the importance of building a resilient innovation pipeline, and points out the first adopter advantage for emerging disruptive technology. The development of this technology could not be more prevalent in the world of geopolitics and deterrence today. Two core areas; addressing fragmentation of researchers, academia, start-ups and governments at the beginning of this pipeline (managing uncertainty), and being able to adopt and scale these new technologies as and when they are ready are emphasized as core areas of concern[4]. A recent article by the innovation unit, citing a RAND report[5], distinguishes between types of applications (Enterprize AI, Mission Support AI, and Operational AI) and discusses new and well-designed principles and practices relating to good governance and responsible use[6]. Therefore, it is vital for military professionals to acquire a solid recognition of AI systems and accompanying new-breed decision-making concepts, as part of the first adopter endeavour.

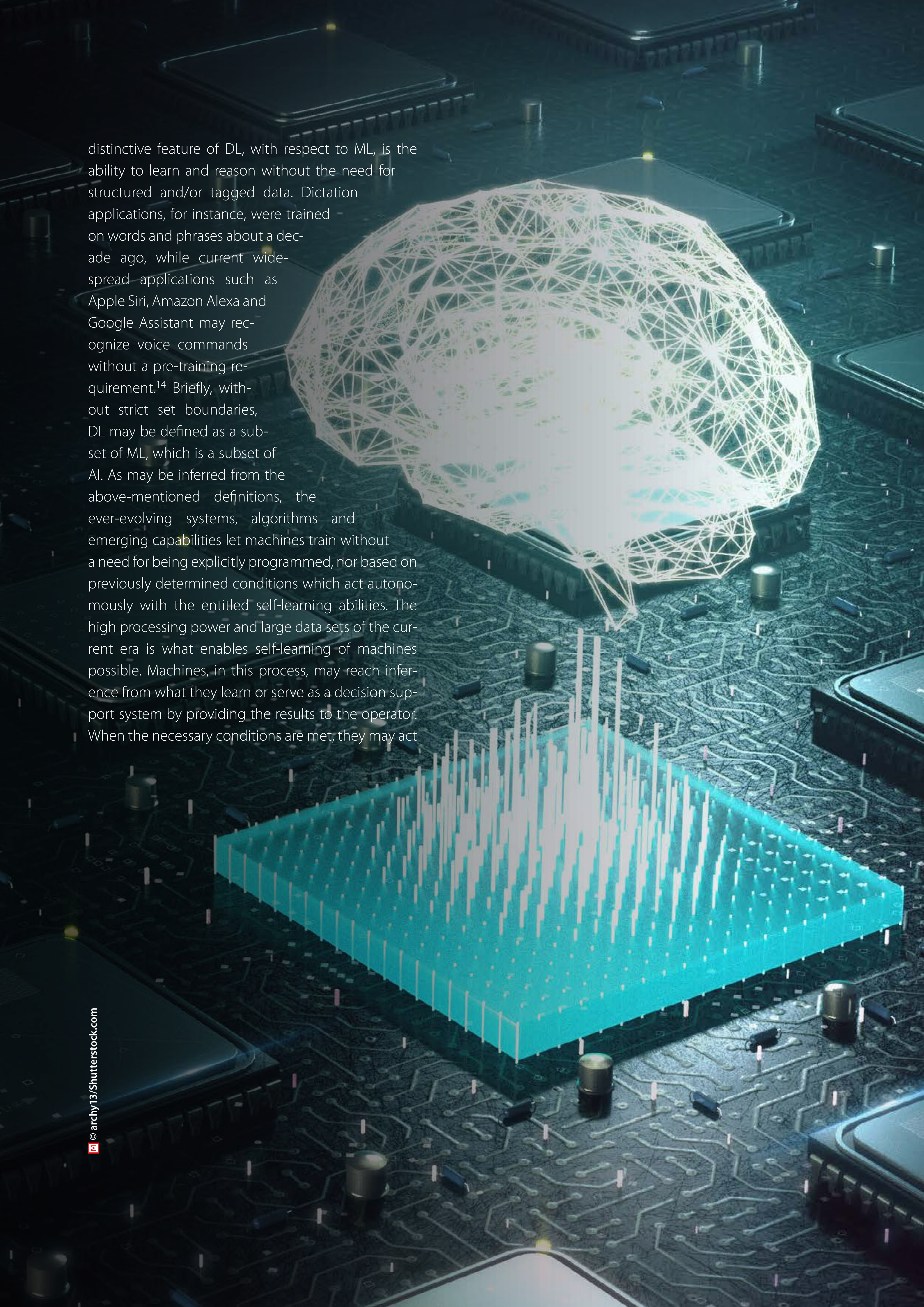
Learning and Decision-Making Machines

During the last half-century, intelligent systems have become inevitable elements of human life. There is an ongoing and accelerating trend of transferring tough decisions to intelligent systems. Humans leverage the acquired comfort of this hassle transfer, especially where prompt judgments under complex and stressful environments need to be executed. Machines have proven to be more efficient and consistent under such conditions. Financial markets have been one of the early and proven examples of algorithms taking over the decision authority from human actors, with the ever-increasing volume of high-frequency algorithmic transactions. In a Bloomberg article, NASDAQ, one of the most efficient stock markets with more than 20 million transactions taking place every day[7], was referred to as 'belonging to the bots'[8]. In the corresponding science literature there has been a century-wide spread of research on organizational structures, data processing tools and techniques, the benefits of technology to decision-making, as well as potential harms of utilizing decision supporting machines.[9] Although this phenomenon has been investigated for a relatively long period of time, breathtaking innovations observed in the field of big data analysis and Machine Learning (ML) have led commercial and public sector researchers to convey their focus to research and development efforts to the field in the last few years. Advanced algorithms, large data sets and systems with high processing power facilitating efficient calculations and inference opportunities using these data sets, enabled the execution of complex tasks that it was previously believed would always require human intelligence.

Turkish mathematician Cahit Arf (Professor Ordinarius), in a public conference aimed to spread university studies to the public perimeter in Erzurum – 1959 pointed:

> '(…) we would then say our brain can solve problems it has never come up with before, or at least we think it did not. However, machines don't have this. I believe the brain's characteristic attribute is its capability of adapting to new, or what we believe is new conditions. Therefore, we need to be willing to understand this: can a machine with adaption capability be built; in other words, a machine that may solve problems that were not explicitly considered while it was being designed, and how? (…)' [10]

Since the speech of Arf more than six decades ago, the same question stands. The frontrunners of popular science discussions; AI, ML, and Deep Learning (DL) have been vague concepts, which indeed do not have strict boundaries between each other. Although the notion of AI was first introduced in academia during the late 1950s, the survey on the perception ability of machines is far older. It is well admitted that computers can carry out logical transactions. However, the question of whether machines can think has always been controversial.[11] The widespread definition of AI has been the 'ability of a computer or machine to mimic the capabilities of the human mind.'[12] On the other hand, ML, a branch of AI, focuses on building applications that learn from data and improve their accuracy over time without being programmed to do so.[13] A relatively emerging concept and a subset of ML, DL multi-layered neural networks as described by IBM are modelled to function like the human brain and learn from large amounts of data. The main distinctive feature of DL, with respect to ML, is the ability to learn and reason without the need for structured and/or tagged data. Dictation applications, for instance, were trained on words and phrases about a decade ago, while current widespread applications such as Apple Siri, Amazon Alexa and Google Assistant may recognize voice commands without a pre-training requirement.[14] Briefly, without strict set boundaries, DL may be defined as a subset of ML, which is a subset of AI. As may be inferred from the above-mentioned definitions, the ever-evolving systems, algorithms and emerging capabilities let machines train without a need for being explicitly programmed, nor based on previously determined conditions which act autonomously with the entitled self-learning abilities. The high processing power and large data sets of the current era is what enables self-learning of machines possible. Machines, in this process, may reach inference from what they learn or serve as a decision support system by providing the results to the operator. When the necessary conditions are met, they may act



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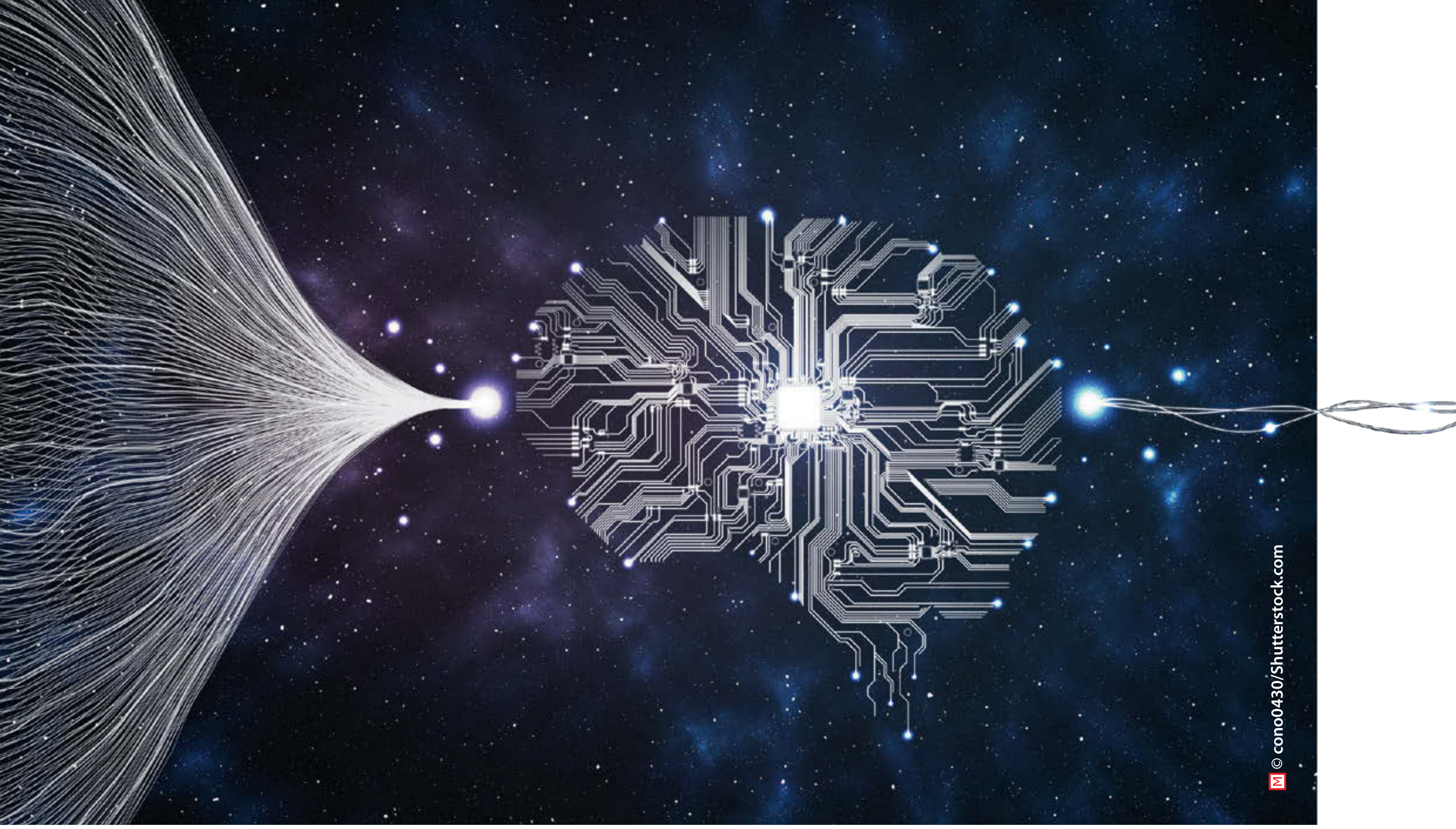

autonomously and without external operator interference. Following the decisions made by the machine, typical feedback algorithms may be used to optimize those same algorithms and the systems. Data produced by humans, specifically personal data, is being increasingly exposed to learning algorithms utilizing big data analysis and ML/DL systems (i.e., search engines, targeted advertisements, and movie recommendations). Successful high-grade graduates of relevant university programmes are hired by technology firms with titles beginning with 'data-' and paid higher salaries than most government and military specialists. This subsequently impacts the survey of AI and ML specialists for defence projects.

The Advent of Deep Learning

The notion of DL is a relatively new concept that stepped strikingly into the ML realm in the last decade. The reason for this late introduction is the requirement of state-of-the-art neural network algorithms being fed by amounts of data large enough from which to actually learn. High digitization of society, leading to large amounts of data fusion, has let researchers utilize computer hardware with high computational power to exploit big data, which in due time drew the attention of governments and military institutions. During this fast process of DL development, algorithmic leaps have recently opened up new aspects for processing large batches of data. As the architects of these advancing state-of-the-art systems, humans are at a decisive point whether to delegate authority to machines to take action without interference in critical situations or not. This becomes even more crucial in fields such as healthcare and defence. There are many applications of widely researched DL areas such as natural language processing, semantic analysis, pattern recognition, and demographic analysis that are used for military intelligence. Nonetheless, it is relatively harder to predict the employment of learning algorithms in autonomous decision-making systems in the military.

An early example of autonomous machines, with a very narrow error margin, has been self-driving cars. In March 2018, the New York Times reported a fatal accident caused by a self-driving 'Uber' in Arizona, which was recorded as the first pedestrian death associated with self-driving technology.[15] This worrisome incident unveiled reasons to survey gaps and search for solutions on the reliability of intelligent machines and in the fields of ethics and justice. The answer to the question of how to account for damages caused by autonomous systems is still vague. On the contrary, predictive policing is an emerging notion from the law enforcement side of the machine learning realm, where quantitative techniques[16] or ML models are utilized to identify 'likely' targets for intervention and prevent crime, or solve past crimes.[17] The use of machines for the prediction of crime areas and potential criminals, reminding us of the movie 'Minority Report'[18], obviously brings along ethical considerations as well.

Harnessing AI

In the Air and Space domains, ML applications gained traction with the introduction of a new generation of manned and unmanned platforms. Exponentially increasing volumes of data, being collected from multiple sensors, gave rise to the requirement for solutions to infer meaningful output from the raw and complex data. Literature in academia has already concluded that DL applications outperform classical statistical techniques in several areas (i.e., Maintenance, Repair and Overhaul [MRO]) of air platforms.[19] The United States Department of Defense publication of 2018, 'Harnessing AI to Advance Our Security and Prosperity' argues that evolving technology has the potential to alter the structure of the battlefield in the near future and will introduce new challenges and threats. Emphasizing the potential AI technology breeds, the study supports the widely accepted idea of multidisciplinary and inter-organizational collaboration among public, private sector and academia partnerships for successful results.[20] It is inevitable that DL applications will be employed to harness data from the high-volume raw data pool generated by, initially friendly, new generation platforms. The inherent ability of these algorithms to classify and process untagged data, and the high efficiency of natural language and image recognition applications draws attention to the potential defence-focused uses starting with the intelligence domain, and beyond. Limited studies of DL uses in military intelligence indicate the already increasing efficiency of proposed applications.[21] DL enables innovative and inspiring solutions such as audio-based drone detection leveraging the high data processing power instead of visual recognition.[22] The increasing acknowledgement rate of AI, ML, Big Data, Human on the Loop (HOTL), Human in the Loop (HITL), Human out of the Loop (HOOTL) as new and/or emerging technologies in documents depicts the future battlespace environments[23]. HOTL, for example, could be argued as a solution to overcome the ethical liability prospects in conflict. This proposes an AI system can provide management options in battle, compliant with the rules of engagement, and give humans the possibility of vetoing options to ensure meeting the ethical requirements [24].

Conclusion

Big data and learning algorithms are being utilized by governments, military institutions and commercial organizations at an ever-increasing rate. Innovations observed in the implementation of decisions by AI range from autonomous vehicles to smart speakers, medical diagnosis to crime mapping, autonomous commercial Unmanned Aerial Systems to military fighter platforms. The drastic and expedited shift in decision authority ownership brings about ethical and judicial issues, and the requirement of swift orientation by decision makers at every level. In a not-so-distant future, not only will the sensing and computing capabilities of AI systems keep increasing at an exponential rate, but also systems may gain the capacity to mimic social and emotional capabilities of humans and make decisions indistinguishable from their human counterparts.

Playing an important role in establishing interoperability standards and norms of use in the military applications of artificial intelligence[25], NATO is on the verge of keeping the technological advantage and being the early adopter, as well as striving to meet the moral requirements which might not be the adversary's primary concern. The vital point to query through this process is not the accuracy of the decisions made by machines, but the consequences of erroneous decisions on ethical and judiciary grounds. Some decisions are as difficult to delegate to machines as they are complicated to be made by humans. The Trolley Problem[26] lays out the dilemma of utilitarianism versus deontological ethics very well by the illustration of self-driving vehicles in an inevitable crash scenario. Considering the consequences of critical decision problems in the military realm, which could be vital in the battlefield, the risks as well as the advantages of AI should be strictly evaluated. These relatively new operational decision-making actors portend a dramatic change of battlefield dynamics, which will take place starting with the shared authority allocation. Human actors will gradually become subsidiaries as the domains become more highly complex, involving numerous constraints and requiring tough and rapid decisions. The state-of-the-art AI systems, which have now gone far beyond Deep Blue beating a Chess Grandmaster, are prone to be the new commanding entities of the battlefield with the capability of evaluating high-volume data-derived outputs in milliseconds, meaning faster and most of the time more accurate and robust decisions. Every emerging platform will potentially increase the requirement to delegate the decision authority to machines further. Sustaining a competent Air and Space Power in the future is only possible by considering the influence of new decision makers on the battlefield, adapting the traditional C2 structure accordingly, and leveraging a synergy of collaboration between governments, commercial actors, and academia. ●

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Aeromedical Evacuation in NATO

Where is the Alliance?

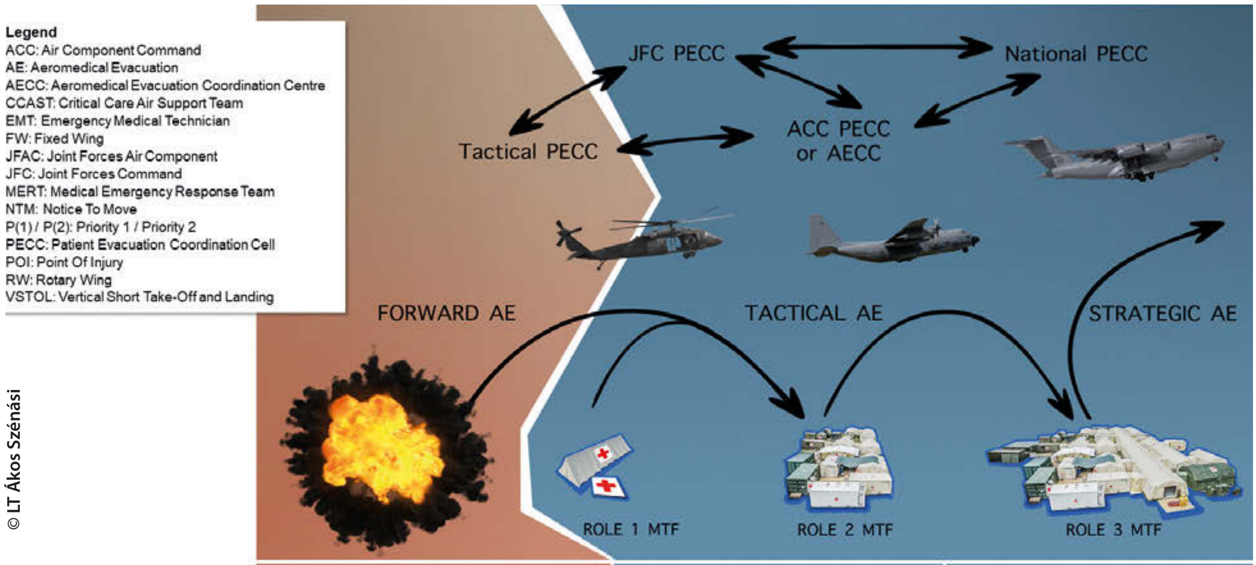
By Major Jacopo Frassini, MD, IT AF, NATO MILMED COE
By Colonel Petr Kral, MD, CZ A, NATO MILMED COE

The Allied Aeromedical Architecture

According to the NATO terminology database, Aeromedical Evacuation (AE) is the movement of patients under medical supervision by air transport to and between Medical Treatment Facilities (MTFs) as an integral part of the treatment continuum.[1] In this definition, 'patients' refers to individuals admitted to care when entering the healthcare system for diagnosis or treatment, 'medical supervision' identifies the medical contribution in the regulating process of patients and 'treatment continuum' means the uninterrupted, progressive, and appropriate medical attention and response to the needs of patients throughout the chain of their medical treatment and evacuation. These three concepts together make AE a medical responsibility.

AE is divided in three phases.[2]

- Forward AE (FwdAE) provides 'the movement of casualties in an air platform with medical personnel from point of injury and/or illness to the first medical treatment facility.'
- Tactical AE (TacAE) represents 'the intra-theatre movement of patients in an air platform with medical personnel between medical treatment facilities.'
- Strategic AE (StratAE) corresponds to 'the inter-theatre movement of patients in an air platform under the supervision of medical personnel from the area of operations to medical treatment facilities outside the area of operations or between medical treatment facilities outside the area of operations.'



	FORWARD AE	TACTICAL AE	STRATEGIC AE
Mission Task	From the POI to the first MTF	between MTFs within the Theatre of operations.	from MTFs in the Theatre of operations to homeland MTFs
STANAG #ref	2087	3204	
High-risk mix	Yes	normally No	No
Assets	RW / VSTOL	FW (RW / VSTOL)	FW
Medical Purpose	Fastest transfer to MTF	Benefit for the transfer must be balanced against the ability to withstand the flight	
AE Teams	1EMT » MERT	MERT or CCAST tailored on clinical needs	CCAST according to National Standards
Asset OPCON	Regional or Component Command	Theatre relevant Operational Command (generally JFAC/ACC)	National Command
Pt Regulating	PECC network mirroring Asset OPCON Commands, coordinating with JFC PECC		
Timeliness	NATO 10-1-2(+2) timeline for critical patients		NTM<12h (P1) - NTM<24h (P2)
Operational Requirements	Medical situational awareness - Evacuation system available in all weather/sea conditions, day/night, any operational circumstances (AJP-4.10)		

Figure 1: The architecture of the AE system in the continuum of care and a possible flow of medical information in a deployed PECC network.

TacAE and StratAE are addressed by the same document, the Standardization Agreement (STANAG) 3204, due to their similarities in mission design.[3] They are usually not high-risk missions, generally performed on FW assets after a formal fitness for flight travel is issued by a flight surgeon or a medical officer qualified in aerospace medicine. Patients are assessed against their condition to survive the air transfer and provided with the specific kind of en route care they need. AE Teams are selected to deliver in transit care in accordance with prevailing medical standards at the same or higher level as provided by the originating unit.[4] Typically, Medical Emergency Response Teams (MERT) and Critical Care Air Support Teams (CCAST) are physician-led AE teams of doctors, nurses and technicians (mostly providers with a background in critical/intensive care, anaesthesiology and emergency medicine) trained by the Air Force to support high-dependency patients in-flight.[5]

According to STANAG 2087, FwdAE is performed mainly by RW or VSTOL assets. The primary mission objective is the retrieval of severely injured casualties from the prehospital environment to a MTF as quickly as possible with essential on-board medical personnel.[6] TacAE and StratAE missions are regulated respectively by Theatre, National and Multinational-level Operational Centres while FwdAE platforms are controlled by Regional or Component Commands.[7] The proper medical information to determine the timeliness and the prioritization of transfers is provided by the network of Patient Evacuation Coordination Cells (PECC), which constantly monitors the readiness status of the healthcare facilities and assets, tracks patient movements and optimizes patient flows among different stages of care.[8] Normally, each command establishes a PECC in the Joint Operations Centre (JOC) where the current medical situation is constantly updated for the competent commanding authority and JFC PECC. Air Commands generally include the PECC functions within the Aeromedical Evacuation Coordination Centre (AECC). The PECC reports to J3 for the execution of AE missions but has constant access to the Joint Medical (JMED) Branch for advice to ensure that the medical requirements are properly included in the planning, execution and adaptation phases of AE missions for each course of action.[9]

Allied Standards

AE systems have the advantage of connecting medical capabilities over a wide territory and facilitate the distribution of specialized resources. In order to comply with the agreed-upon allied standards, especially for the early stages of care in emergency situations, patients should access the proper MTF at the proper time. In modern allied warfare, air assets operate relative safety in the context of air supremacy, quickly connecting MTFs to the fighting force. The perception of a controllable operational risk encouraged the adoption of civilian prehospital standards (i.e. the golden hour principle) to improve patient outcomes as reasonable solutions, even for deployed military settings. One of the most successful improvements derived from the civilian legacy is the NATO 10-1-2(+2) timeline.[10]

The NATO 10-1-2(+2) timeline displays the critical interventions that need to be considered for completing all resuscitative stages in the continuum of care:

10 minutes of injury or onset of severe symptoms for bystanders to deliver effective first aid, bleeding and airway control to the most severely injured casualties.

1 hour of injury or onset of acute symptoms to provide medical service personnel, qualified, trained and equipped for emergency care to start advanced resuscitation and pre-hospital emergency care

2 hours of injury or onset of acute symptoms to provide medical service personnel qualified, trained and equipped for surgical and resuscitative emergency care to complement prehospital emergency care by life limb and function preserving surgical and resuscitative procedures as soon as possible

+2 hours of tactical evacuation after initial treatment to provide further surgical, resuscitative, diagnostic and specialist care capabilities necessary to stabilize the patient for strategic evacuation.

Those times are depicted on a map as Medical Evacuation (MEDEVAC) rings, representing the area of terrain that is covered by the AE platforms to deliver the agreed standard. MEDEVAC rings are the main determinants of the Medical Common Operational Picture (MEDCOP), a visual chart where medical infrastructure, core capabilities, readiness states and assets are displayed (Figure 2).

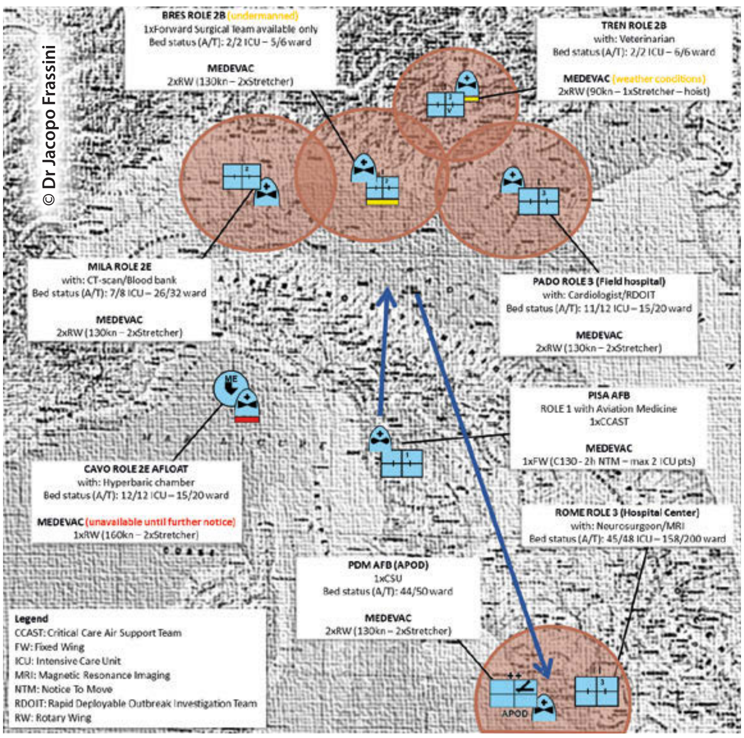


Figure 2: An example of MEDCOP (fictional), displaying medical assets and facilities with their most relevant features and updated readiness status.

It is important to note that the allied MEDEVAC rings are calculated from the moment of injury/sickness and represent the limit to provide initial surgery in a FwdAE loop. In order to show clinical information to medical decision makers, MEDEVAC rings not only represent the specifications of air assets (i.e. cruise speed), but also include other operational/medical variables, such as reporting times from the unit, processing of requests by the PECC/JOC, ground handling and care of patients until handover to the destination MTF. Different platforms offer different cabin arrangements, equipment, payload, total number of crew members and capacity to evacuate patients. Combinations of these options are important to enable a certain level of en route care and accomplish medical mission success.

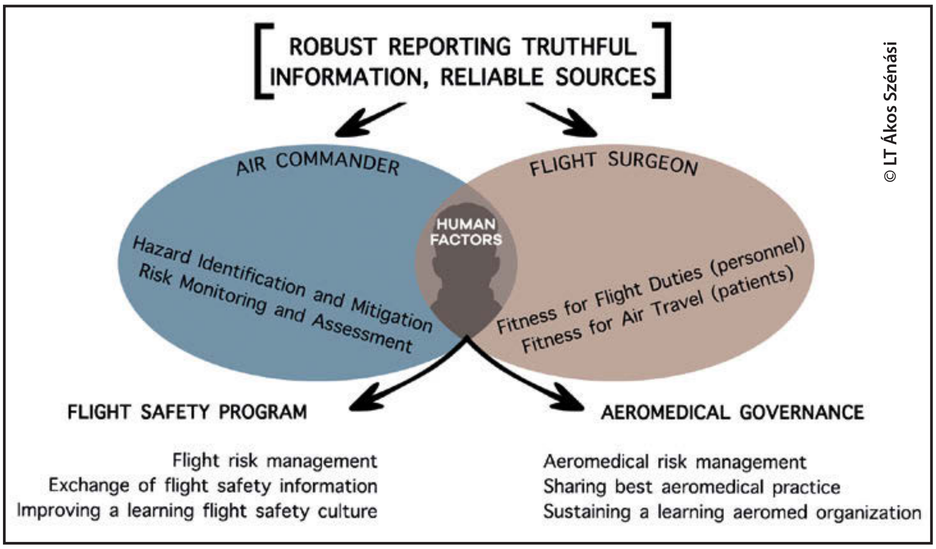


Figure 3: Similarities between a Flight Safety Program and an Aeromedical Governance Framework.

The Nations perform StratAE according to the patient priority soon after the Patient Movement Request (PMR) is issued by the treating MTF or by the Casualty Staging Unit (CSU) for patients with minor conditions.[11] When augmented with aerospace medicine capabilities, CSUs are commonly referred to as Aeromedical Staging Units (ASU), which are stationed at major air-hubs serving as buffers allowing stabilized patients to be rapidly prepared for flight as soon as aircraft become available. StratAE missions are long-range transfers of stabilized patients. The preparation of patients must be synchronized with the readiness of the assets and matched with the proper cabin configuration and on-board assistance. In these conditions, patient outcomes are related to the quality of the aeromedical support compared to speed of accessing the next level of intervention. StratAE is calculated in Notice to Move (NTM) times, identifying the limit to initiate the mission (i.e. less than 12 hours for a priority 1). Experience proved that patients can reach homeland facilities in less than 72 hours of wounding with an efficient coordination of the three stages of AE.

Shaping Quality in AE Systems

The three phases of AE are essential components in the modern design of a NATO healthcare architecture to the point that a standard allied evacuation system has been agreed to be available in all weather and sea conditions, at day and night, and in any operational circumstances.[12] However, realistic limitations on readiness are very common due to safety concerns and reaction times become significantly longer than expected. Evacuation systems are flexible networks where ground, maritime and air assets are constantly adapted to deliver the continuum of care to the supported force. Generally accepted timelines can be used as planning references in order to best allocate medical resources and shape the deployed emergency medical system in the battlespace, yet some specific situations require dynamic approaches or dedicated solutions to still meet those standards or further optimize medical outcomes. Air operations must be effective, sustainable and safe, where safety in combat is not riskless, but free of preventable hazards. Risk management is conducted through a trusted reporting system better known as the Flight Safety Program[13] that represents the main learning component in the allied aviation safety strategy to support decision-making processes of commanders at all levels. The Flight Safety Program is based on a direct channel of communication from flying units to decision makers concerning safety issues that might have endangered the mission and can contribute to maintain risk awareness adherent to evolving combat conditions. Information needs to be shared and passed from originators to higher formations so that the overall picture can be analyzed for wider application and harmonized among all contributors to enable safety outcomes. Remedial actions or simple recommendations are generated to improve collective awareness of a hazard, identify solutions and avoid the repetition of adverse occurrences. Aeromedical governance is a similar process applied by flight surgeons to deliver quality in AEs, so that patient outcomes are constantly monitored and optimized by integrating medical and operational solutions to accomplish specific clinical requirements.[14] AE is a core component in modern healthcare support to operations, yet it represents only a part of the continuum of care that needs to be harmonized when connecting consecutive stages of the treatment chain from the battlefield to homeland hospitals.

All medical inputs and outputs of operational commands cannot be fully effective without accountability in providing a continuous improvement of healthcare support. As outlined in Figure 4, the green area depicts the resulting main area of national responsibility for capability development and care delivery in NATO operations. The brown area shows where national accountability is shared among more Allied Nations operating in the same combat zone with pre-deployment agreements. In the blue area, the basic responsibility handed over to NATO commanders upon transfer of authority. Such a fragmented scenario poses a risk to aeromedical governance that should be able to fluently regulate casualties throughout the continuum of care. The provision of some kind of care alone does not directly imply best patient outcomes, most importantly in complex multinational environments.

In Allied deployments, operational commanders face the difficult challenge to harmonize the medical common operational picture so that the resulting integrated system of care is enabled to guide and track patients over time through a comprehensive array of health services by consecutive and increasing levels of intensity of medical interventions.[16] Performance indicators (i.e. MEDEVAC mission total time) are basic tools for assessing, monitoring and optimizing quality of care. In military systems, medicine is not a stand-alone discipline but needs strong integration in the command and control structure to provide medical support services that frequently result from a coordinated sequence of medical interventions delivered in different moments and places. As a consequence, performance indicators are a combination of clinical and operational figures and require unique expertise to correctly and effectively analyze their meaning in a combat environment.

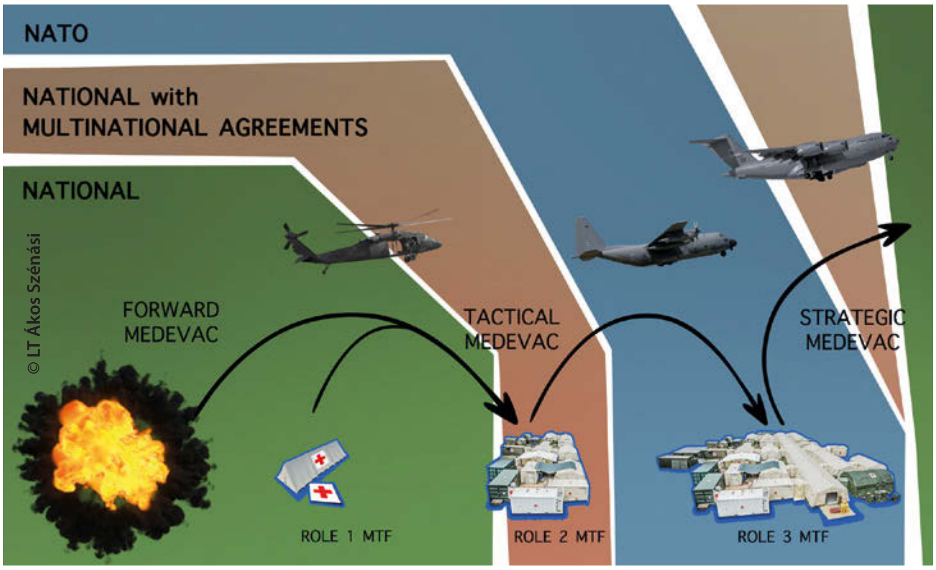
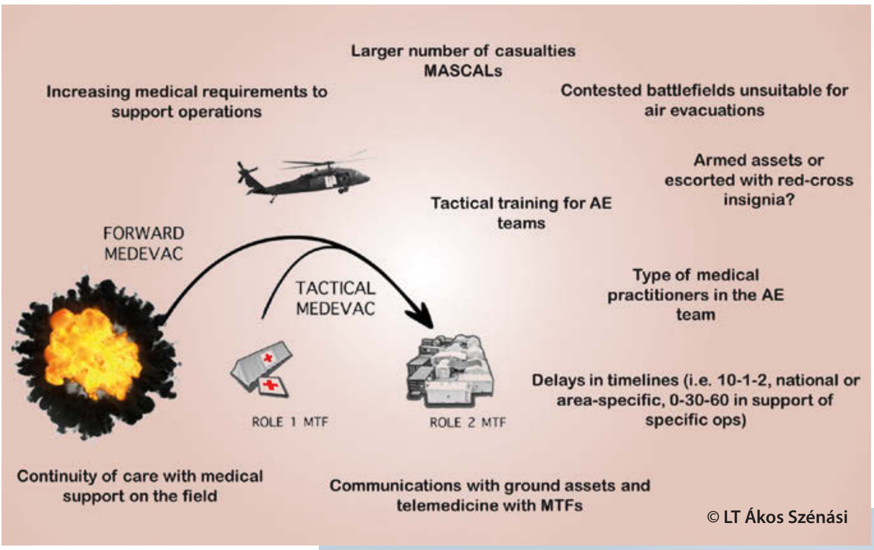


Figure 4: A simplified separation of accountability in the provision of the continuum of care in allied operations.[15]

Outlook

Future challenges are strongly influenced by the evolution of warfare and combat threats. Hybrid warfare scenarios against increasing technologically capable adversaries in possibly denied areas of interventions will pose serious limitations to the flexibility of traditional aeromedical platforms to connect stages of care.[17] In particular, constraints on availability



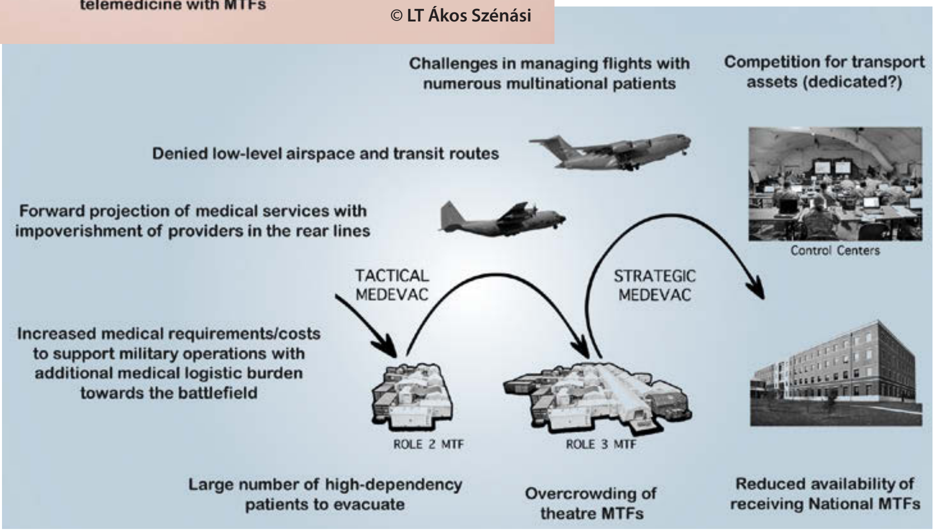


Figure 5: Illustrative list of possible AE challenges in the future global security environment.

and mobility of aeromedical assets will require a serious approach to alternative solutions to sustain the currently expected patient outcomes and the continuity of care. Some of the challenges may be prevalent in the FwdAE phase, which is the most exposed to low-level airspace threats. However, TactAE and StratAE phases will also encounter difficulties in the regular transfer of patients in contested battlespaces. In multinational environments, interoperability of assets, facilities, procedures, equipment and personnel is a key enabler of the healthcare support across the whole range of deployed capabilities.[18] Recent studies showed how joining military forces with different backgrounds generates the risk of duplication, overcapacity and barriers in procurement that can reach 15 % of the total budget.[19] All NATO countries together represent the world's leading alliance in defence spending. However, multinational military systems like the EU use up to 17 different types of assets compared to single nation organizations like the US.[20] Heterogeneity in the spectrum of available capabilities generates additional implied costs and increased organizational efforts for sustainment and interoperability during combined campaigns.

Multinational healthcare systems require long-term planning of dedicated resources to support the operational requirements with the agreed standards of care. To achieve best patient outcomes, aeromedical capabilities need flexible development strategies to continuously harmonize technological progress, evolving evidence in medical practice and the context of future warfare scenarios. As advocated by the NATO Smart Defence initiative, multinational solutions must result from a coordinated planning approach, specialization/modularity and prioritization of investments across the Alliance.[21] Consequently, Nations can synchronize individual projects cost-efficiently and grow cohesive understanding to meet the security challenges of the 21st century.

Conclusion

AE in NATO operations is a core enabling function for mission success. Its architecture as depicted in AJP-4.10 and related medical STANAGS ensures that a casualty is retrieved from the prehospital environment and transferred via the continuum of care through to rehabilitation. Allied aeromedical standards create the best agreed-upon conditions to deliver the right treatment in the right place at the right time. Best patient outcomes result when allied standards are continuously adapted to the battlespace and when the quality of healthcare can be monitored, analyzed and improved. However, AE assets cannot be improvized to accomplish their clinical support mission, especially in multinational contexts. Our recommendation is to consider AE as a dedicated medical support capability to be planned, developed, manned, trained, exercised and controlled collectively in order to achieve both economy of scale and optimized medical outcomes.

Acknowledgements

Special thanks to LT Ákos Szénási for the restyling of figures 1, 3, 4 and 5.

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Major Jacopo Frassini, MD

is a flight surgeon of the Italian Air Force since 2006 and holds a Private Pilot License. He specialized in cardiology at Padua University and is currently assigned to the NATO Centre of Excellence for Military Medicine. He previously served as a base physician at the Aerospace Operations Command in Poggio Renatico AFB (Ferrara, ITA – 2006–2019). As a medical officer, he supported operations in Afghanistan (2010; 2012; 2014), Libya (2011), Kuwait (2014), Lebanon (2017; 2019) and Iraq (2018), deploying with both regular and special forces. He also participated in numerous exercises of the Joint Air Forces Component (ITA-JFAC) at national and international level (Virtual Flag 2013 and 2014 – NATO Trident Juncture 2015 – Joint Virtual Flag 2016) either in Current Ops Division or as Medical Advisor to the Air Commander.

Colonel (GS) Petr Král, MD

graduated from Charles University and the Military Medical Academy Hradec Kralove (medical faculty) in 1993. He went on and completed speciality training in family medicine and military medical service management (board certificates). His 28-year military medicine career has been focused on assignments as a physician and medical staff officer, including deployments in EU and NATO missions. He served as the Joint Medical Coordinator at NATO JFC HQ Brunssum (2009–2012) and most recently as the Director of the Military Medicine Department in the CZE MOD (2016–2018). He is currently serving as Chief of Interoperability Branch at the NATO Centre of Excellence for Military Medicine in Budapest, Hungary.

The JAPCC Hosts Annual Think Tank Forum in a Virtual Environment

Ongoing Collaboration Efforts Despite the Pandemic

The Think Tank Forum has evolved for the last eight years with the motive of gathering the collective expertise of Air Warfare Centres, Think Tanks and similar national organizations concerned with Air and Space Power topics. As usual, we pursued this endeavour to identify common challenges that most urgently need to be tackled and identify opportunities for co-operation and collaboration for more efficient and effective utilization of our combined human capital.

The COVID-19 pandemic situation that caused the cancellation of the previous Think Tank Forum is unfortunately still ongoing. Therefore, this year's event on 24–25 March 2021 was planned in a virtual setting in the same manner as the latest Joint Air and Space Power Network Meeting (JASPN); a sister event to the TTF which gathers NATO, EU and other multinational organizations together with the same purpose. The two events are separated only to maintain a manageable scale.

Virtual meeting represents a new way of doing business in the times of COVID and was successful in getting participants connected as a team to find areas of common interest and collaboration. Emphasizing the benefits and added value of face-to-face discussions, the Think Tank Forum 2021 in the virtual setting had been an alternative yet successful way of getting together valuable experts from different nations and organizations and engaging in collaborative discussions.

This year's TTF was carried out with the valuable contributions from 14 organizations of 11 nations. The highest-interest topics touched-upon by the participants this year included C-UAS, Space, F-35 Training, Cyber Security & Training, Air C2, Artificial Intelligence, Next Generation Air Platforms, Doctrine, Industry & Civil Cooperation, JADO & JAD C2, Arctic, Agile Combat Development, and EMS Operations. JAPCC has been resilient and has successfully sustained our activity level in this time of the pandemic and will continue to be productive in the future. We are looking forward to next year and hope to again be able to carry on collaborative discussions with our colleagues in a face-to-face environment.

Just a reminder …

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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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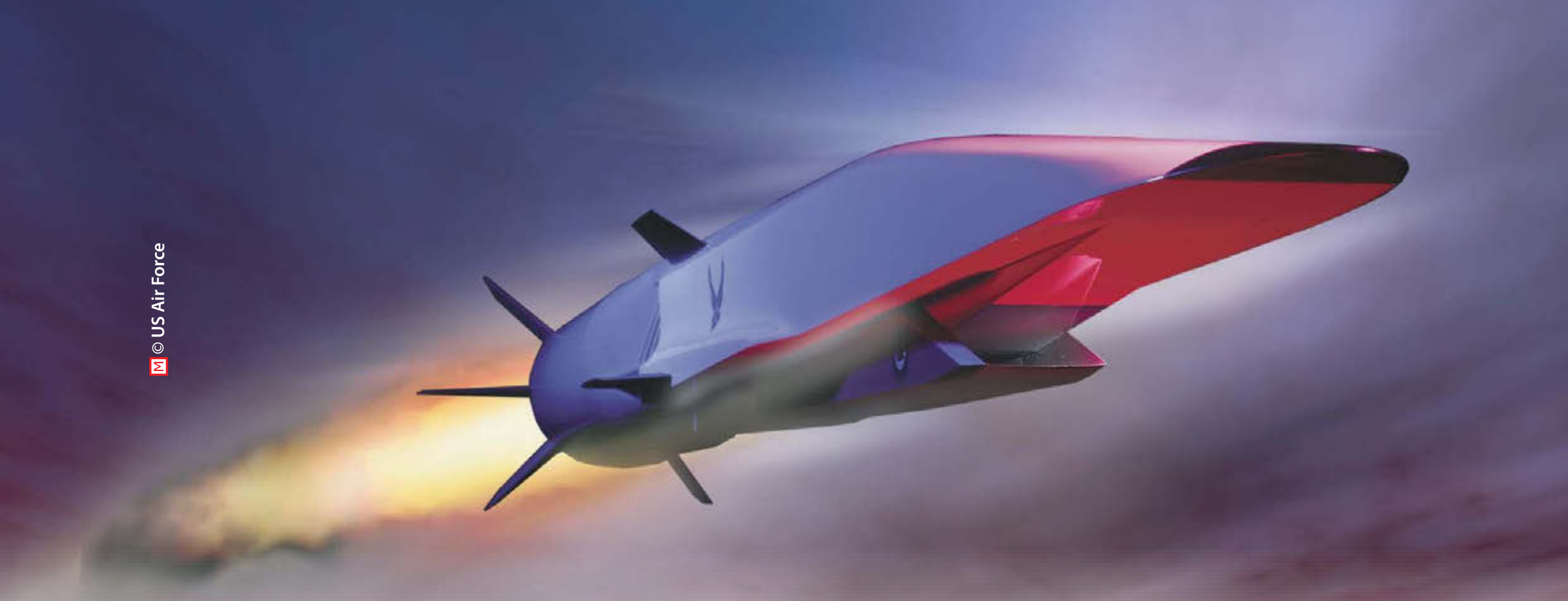

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Exploring the Impact of Hypersonic Effects

As a constant in military matters, there are always new technologies, procedures or tactics emerging on the proverbial horizon. Many of the more prominent headlines of the past few years have revolved around hypersonic capabilities and how they might be 'game changers' in modern warfare. JAPCC was asked by the NATO Science and Technology Organization in early 2018 to support a comprehensive study concerning hypersonic threats. Since that day, our understanding of what hypersonic weapons can or cannot achieve based on technological possibilities and limitations has evolved along with the capabilities themselves. With a growing idea of the 'What' and 'How' of this emerging technology, we are also getting much better at assessing the 'So What' of this potential 'game changer'. Subsequently, this allows for educated discussions of what NATO or individual nations might need to counter this threat or which hypersonic capabilities are a meaningful addition to NATO's repository. Fostering and growing a fundamental knowledge base about hypersonic technology has allowed JAPCC to contribute in a multitude of national and international projects, studies, exercises and experiments. This led to a better depiction of hypersonic weapons and their consequences on current defensive postures in NATO exercises like Ramstein Ambition or international Missile Defence experiments such as Nimble Titan, allowing for more meaningful player interaction, observations, conclusions and lessons learned. Also, this enabled JAPCC to successfully contribute to various national (e.g. GE Luftmachtseminar) and NATO studies about missile threats and the role of missile defences in relation to hypersonic threats. In early 2020, JAPCC was asked to co-chair the current NATO STO study (AVT-359) of this still pressing issue. This ensures a more thorough integration of research and industry experts with the military community, adding needed focus on the political and military facets necessary to derive strategic, operational and tactical decisions for future deterrence postures, military operations and procurement. Due to the continuing relevance of this topic, JAPCC is regularly asked to give presentations to high-level committees (e.g. Air and Missile Defence Committee), multinational conferences (e.g. CC SBAMD conference) or national education centres (e.g. GE Command and Staff College). Furthermore, JAPCC provides recurring support to students from national and NATO educational institutions (e.g. NATO Defence College) with papers related to hypersonic threats. Not only is it an honour to be asked to contribute to matters of such importance, but it highlights the benefits of NATO having centres of excellence like the JAPCC. Here, subject matter experts are empowered to freely deep dive into individual topics like hypersonic capabilities, force protection, air mobility and more, and connect them with national activities and NATO disciplines to improve general understanding and consequently the overall security environment.

Space Branch Activities in Promoting NATO's Newest Operational Domain

NATO's dependence on Space-based capabilities is not new; NATO has been relying on these capabilities for decades to position and track forces, to communicate beyond line of sight, to detect missile launches, and to ensure effective command and control. However, these Space-based capabilities were not always included into operational planning and execution processes. By recognizing Space as an Operational Domain in 2019, the Alliance political decision makers, and the strategic and operational commanders, recognized the need to engage more actively in a coordinated approach to operations involving support from the Space domain. The implementation process is an ongoing and challenging task for NATO.

While inside the NATO Command Structure (NCS) adaptations like the Space Centre and the increase of personnel are still on the agenda, entities of the NATO Force Structure (NFS) have started initial activities for increased integration of Space into their daily battle-rhythm.

The First German Netherlands Corps (1st GNC) in Muenster, Germany, can be seen as an example for these efforts in their development of a Warfighting Corps Headquarters for NATO. The 1st GNC is increasing general Space awareness as well as assessing and analyzing the domain for further mission planning, preparation and execution for land forces at the corps-level. The JAPCC supported a warfighting conference of 1st GNC in March 2021 by providing of a virtual lecture on NATO's approach to Space, and in April 2021 two Space professionals joined a 2-day Functional Integration Training. The intent of both events was to deepen the audience's knowledge of Space by identifying tasks in the scope of the multi-domain operations concept, and develop scenarios and concepts which included Space aspects and affects.

Integrating Space in all cycles of planning as well as in training of personnel is a must not only in the NCS, but also in the NFS and in national armed forces. The 1st GNC started internally with adapting warfighting concepts and now has included JAPCC personnel who are able to support these endeavours, bringing in their specific expertise and knowledge of Space as well as education and training of personnel in a joint effort.

Three Years as the Assistant Director

From 'New Challenges' and 'Old Threats'

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This is my 6th and final contribution as the editor of our thought-provoking and stimulating Journal of the JAPCC.

During the last three years, I have been privileged to publish more than 75 articles in our Journal, not only discussing the whole spectrum of Air and Space Power, but taking the relevant and necessary steps to further discover and highlight the 'grey' areas or the steps taken to achieving a 'Joint All Domain' effort.

It was a great pleasure to work with our Subject Matter Experts of the JAPCC and especially our external authors with their diverse backgrounds which contributed to this Journal. I learned a lot through this exchange of ideas and experience.

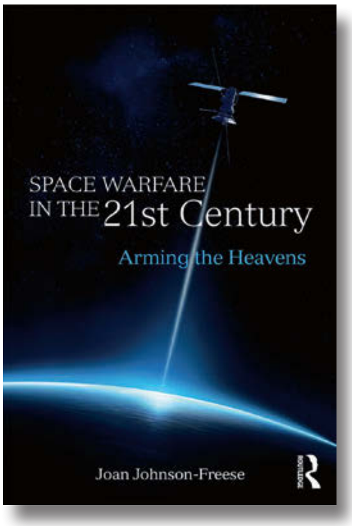
Unfortunately we could not publish all the interesting article submissions we received in the past few years. It is one of my main responsibilities as the editor to decide which articles might be relevant and stimulate our interested readership most and which best addressed our current and upcoming issues. Nevertheless, we are always looking for and welcoming new ideas and interesting topics regarding Air and Space Power.

The Journal of the JAPCC is and will continue to be an informational tool for NATO's military and political decision makers. It is a necessary tool for NATO to highlight successful developments, ongoing projects and training, possible shortcomings and future trends. It also acts as a deterrent in announcing the advancements we make together as an alliance. The Alliance will always be stronger when we are working together and therefore we should not lose the focus on our 'Joint' collaboration.

The need to share thoughts and ideas of our multiple and very unique national backgrounds is paramount. It will counter future challenges in every possible domain and will continue to gain in importance compared to the first 15 years of the JAPCC.

I am very thankful and excited that I have had the chance to lead this outstanding Team of Experts and I am proud of our achievements over the past three years. Considering the 'new challenges' of a worldwide pandemic, we could not be stopped from providing meaningful and relevant products to advance NATO's Air and Space Power. We remain the strongest combined force in the world and we constantly strengthen our credible deterrence and always keeping an eye on 'old threats'.

‘Space Warfare in the 21st Century: Arming the Heavens’



By Joan Johnson-Freese;
Routledge; November 2016
Reviewed by:
Lt Col Tim Vasen,
GE AF, JAPCC

This book uses the current rivalry between the United States and China in their use of Space to critically address and discuss the historical US approach to dominate Space. The US, in the years 1960 to 1970, undertook an approach of ‘stressing the monopoly’ due to financial aspects and relevance of their Space industry. During this time, the US tried to influence other nations and commercial entities due to their monopoly in Space capabilities in the western world. This forced other nations to develop their own Space assets and services, and therefore reduce the dominance of, and their dependence on, the US.

The author, Joan Johnson-Freese, discusses further challenges, vulnerabilities and countermeasures for a high-technology nation that relies significantly on Space-based services, products, and assets. Threats to all military and security related Space assets are thoroughly analyzed. The difference between Space weapons, weaponized Space, as well as counter Space means are addressed, including a discussion on different national perspectives in the debate about placing weapons into Space. Finally, the book dissects the challenges for protecting the nations’ Space power and sustaining its function in the ‘deter, defend, and defeat’ triad.

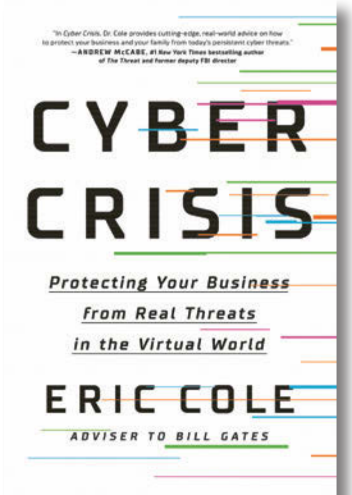
For defence professionals who are active in Space security policy and strategy development and how these topics influence today’s security systems, this book is a must-read.

‘Cyber Crisis’

In the Information Age all of us are reliant upon information technology and the connectedness enabled by Cyberspace. Eric Cole’s Cyber Crisis brings home the point succinctly, that ‘if you want to survive in cyberspace, there are two core rules you need to remember: 1) You are a target; and 2) Cybersecurity is your responsibility’ (p. 12).

Cyber Crisis is written in an easily digestible manner with examples and lessons learned by the author over two decades of working security issues related to information technology. The book focuses on the reality we must all come to realize, and respect, that ‘countries and criminals around the world are currently and consistently engaged in cyberattacks, and because there are no international borders, and it can be done from virtually anywhere, it is a low-risk, high-payoff crime’ (p. 23).

Military members need to understand that not only is the threat real, but that they are both the target and the key vulnerability. Cole notes that compromises will happen and that while safeguarding against them is a worthwhile goal ‘it is critical’ we are prepared ‘to detect and respond in a timely manner’ (p. 235).



By Eric Cole;
BenBella Books; June 2021
Reviewed by:
Lt Col Henry Heren,
US Space Force, JAPCC

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