



LUDOVIKA
UNIVERSITY PRESS

AARMS

ACADEMIC AND APPLIED RESEARCH IN MILITARY
AND PUBLIC MANAGEMENT SCIENCE

Volume 24 (2025)

No. 1

ISSN 2498-5392 (print)
ISSN 2786-0744 (online)

AARMS is a peer-reviewed international scientific journal devoted to reporting original research articles and comprehensive reviews within its scope that encompasses the military, political, economic, environmental and social dimensions of security and public management.

AARMS is published in one volume of three issues per year by the Ludovika University of Public Service, Budapest, Hungary, under the auspices of the Rector of the University.

Articles and other text material published in the journal represent the opinion of the authors and do not necessarily reflect the opinion of the Editors, the Editorial Board, or the Publisher.

All correspondence should be addressed to Prof. József PADÁNYI, DSc, Editor-in-Chief,
Ludovika University of Public Service
P. O. Box 15, H-1581 Budapest 146 Hungary
aarms@uni-nke.hu

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AND PUBLIC MANAGEMENT SCIENCE

Volume 24

No. 1

2025

An International Journal of Security, Strategy, Defence Studies,
Military Technology and Public Management

Published by the Ludovika University of Public Service

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Typeset and print by the Ludovika University of Public Service

ISSN 2498-5392 (print)

ISSN 2786-0744 (online)

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Regional Security and Modernisation Efforts

Comparative Analysis of the V4 Air Forces¹

Laura NYILAS,²  János CSENGERI³ 

The study explores the air forces of the Visegrád Group within the broader framework of regional security studies, focusing on their modernisation efforts and strategic importance in Central and Eastern Europe. Emphasising the interplay between national defence priorities and collective NATO goals, the study examines defence spending, procurement trends and operational capabilities. The research seeks to assess how the modernisation of the V4 air forces contributes to regional stability and to what extent disparities in readiness and capabilities influence collective security. Using a comparative analysis based on the Military Balance + and SIPRI databases, the study evaluates current force structures and procurement trajectories. The findings reveal significant differences in modernisation levels, with Poland leading in both scale and diversity, while Slovakia faces pronounced capability gaps. The study argues that air power serves as a vital element in maintaining regional stability, particularly considering escalating geopolitical tensions, including the ongoing Russia–Ukraine conflict. It also underscores the need for enhanced coordination among the V4 countries to address shared security challenges and strengthen their collective defence posture. This analysis contributes to the discourse on regional security, highlighting the critical role of air force modernisation in fostering resilience and ensuring stability in Central and Eastern Europe.

Keywords: regional security, air force modernisation, Visegrád Group, NATO defence cooperation, Central and Eastern Europe

¹ “Supported by the EKOP-2025-NKE-3-89 university research scholarship programme of the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund.”

² Ludovika University of Public Service, Doctoral School of Military Sciences, e-mail: nyilaslaura98@gmail.com

³ Ludovika University of Public Service, Faculty of Military Sciences and Officer Training, e-mail: csengeri.janos@uni-nke.hu

Introduction

Until recently, the study of security within international relations was dominated by state- and system-level approaches, such as realism and neorealism.⁴ The effect of the realist dominance has been that security interests have typically been interpreted from the perspective of “elite” positions, i.e. “top-down” to “mainstream” approaches. However, the last decade has also seen an emphasis on research that argues that security is a more complex phenomenon, expressed at multiple levels.⁵ More recent research in the field of security (politics) emphasises that security is constructed from other sources, in addition to and outside the state and the international system. Such sources include the individual (human security), the social group (identity and social security) and the region (regional security).⁶

In recent years, the latter, i.e. the region itself as a unit for examining security, has received particular attention.⁷ The region is of particular importance because it implies a level of expression of security needs that is below the international but above the state level. Thus, the study of the region as a unique reference point with its own specificities about security helps to complement the realist tradition of international security studies. Regional security complexes are also crucial for understanding how regional security problems relate to global challenges. David A. Lake and Patrick M. Morgan, in their book *Regional Orders. Building Security in a New World*, argue that these regional orders are not merely regional phenomena, but have global consequences and, where appropriate, shape the strategies and behaviour of states outside the region.⁸

It is important to talk about regional security in 2025 because it remains a critical issue that affects the stability of countries and the security and well-being of their citizens. Recent developments, such as rising geopolitical tensions, in particular the ongoing Russia–Ukraine war, have further underlined the importance of regional security cooperation. Therefore, rising nationalism and geopolitical tensions have underlined the importance of building trust and cooperation between regional actors.⁹

In this context, discussions on regional security have been and will be particularly important in 2024 and 2025, as they can help to identify and propose solutions to emerging security challenges, improve resilience to threats, and promote regional cooperation and integration. Discussions on regional security can also contribute to the understanding of global security by informing the interrelationship between global and regional politics and by making the institution of multilateral cooperation more effective.¹⁰

In this respect, it is arguably important to look at the Central and Eastern European region in 2025. This is why the Visegrád Group is examined in this study. This group of countries, consisting of Hungary, the Czech Republic, Poland and Slovakia, continues to

⁴ BOOTH 2007; SNYDER 2004; MEARSHEIMER 2001.

⁵ TICKNER 1992; BUZAN et al. 1998; WYN 1999; AXWORTHY 2001; WIBBEN 2004; BOOTH 2005.

⁶ LAKE–MORGAN 1997; HENTZ–BØÅS 2003.

⁷ WILSON–SHERWOOD 2000.

⁸ LAKE–MORGAN 1997.

⁹ RADA 2019.

¹⁰ FLEMES 2010; NYE 2017.

play an important role in shaping regional and European policy, which can be interpreted as a kind of preliminary research hypothesis. The V4 countries are located at the intersection of a number of international (global) strategic and economic interests, which makes them key actors in regional and global politics. Their geographic location, as well as their shared history and cultural links, provide unique insights into regional dynamics and the challenges they face together. Moreover, the V4's relationship with neighbouring countries such as Ukraine and Russia is critical to understanding regional stability and security. As tensions in these regions remain heightened, the role of the V4 in promoting dialogue and cooperation, where appropriate, can help prevent further escalation and contribute to a more peaceful and stable Europe. While idealistic, this regional goal remains relevant – not least for ensuring Hungary's security.

In the Central and Eastern European region, the Visegrád Group is one of the oldest regional groupings, established by the Member Countries in 1991 in the wake of the Cold War and the political realities of the liberation from Soviet interests.¹¹ The group has undergone many changes since then, and world political events also have had a major impact on the countries.

Although the cooperation may not have fulfilled all initial expectations, significant successes were achieved in numerous areas. This raises the question of whether the cooperation has been effective and relevant. Naturally, the answer always depends on our expectations. However, it must be acknowledged that the initial practical goal of the cooperation was realised: all four countries involved joined the EU and NATO, meaning that European and transatlantic integration was successful.

The dynamics of cooperation depend to a large extent on the current government and internal political-ideological orientation of the four countries and their relations with each other, and international events have a strong influence on the issue at stake, in addition to domestic political aspects. While the V4 remains an example of regional cooperation guaranteeing good neighbourly relations, they are today facing serious challenges such as migration, the energy and financial crisis, and the Russian–Ukrainian war.¹²

There are, however, major differences in the military capabilities of the four countries, currently focused solely on air power, so that beyond joint NATO or EU Battlegroup exercises, there is no clear sign of cooperation in this area. In order to explore the deeper dimensions of the air forces of the four Visegrád countries, the study analyses the military capabilities of the four countries and comparatively assesses them in this area (air power/aerial warfare). Therefore, the main aim of the study is to investigate how national air force modernisation among the V4 countries affects regional security and NATO cohesion. Secondary aims include identifying differences in air capabilities, procurement strategies and interoperability potential within the group.

Accordingly, the central research question is: to what extent do the modernisation trajectories of the V4 air forces contribute to strengthening regional security and cohesion within NATO? This question is justified by the observable disparities in defence spending

¹¹ STEPPER 2018.

¹² GYÁRFÁSOVÁ 2018.

and procurement priorities, despite shared threats and alliance commitments, and by the growing importance of air power in the evolving European security environment.

The study examines the four countries of the Visegrád Group in the Central and Eastern European region, focusing on air power and its importance. It primarily covers the period between 2022 and 2024, but where necessary, considers earlier and future developments as well. The empirical analysis is based on open-source data, relying principally on the International Institute for Strategic Studies (Military Balance +) and SIPRI Arms Transfers databases. The research uses comparative analysis to assess the composition, procurement trends and readiness of the V4 air forces.

Several recent studies have examined aspects of regional security and NATO alignment, including the impact of Russian aggression on defence postures and the modernisation of individual national forces. However, few have comparatively assessed the air force dimension of the V4 countries as a regional subsystem. This article aims to fill that gap by providing a structured comparison focused specifically on aerial capabilities, procurement and strategic positioning. In doing so, it contributes to a better understanding of how national defence decisions intersect with alliance-level requirements and regional stability imperatives.

The article proceeds as follows: after methodology and the theoretical framework, it presents a comparative analysis of the air forces of the Czech Republic, Hungary, Poland and Slovakia. This is followed by a discussion of defence spending, procurement patterns and operational capabilities, before concluding with a synthesis of findings and their implications for regional and NATO security.

Theoretical framework

The historical role of the air force in maintaining regional stability in Central and Eastern Europe has significantly increased, particularly regarding strategic operations and modernisation efforts. Air forces have played a key role in shaping military doctrines and enhancing defence capabilities, both of which are crucial for regional security.

The establishment of NATO in 1949 marked a significant commitment to European security, placing the air force at the core of its defensive strategy against the Soviet threat. Air operations were crucial both for deterrence and for potential offensive strategies against adversaries, emphasising the importance of air superiority in regional stability. Thus, the role of the air force has been pivotal in maintaining the stability of the Central and Eastern European region, especially since the end of World War II. To this end, the U.S. Air Force has consistently maintained a military presence in the region, reassuring allies and deterring potential aggressors when necessary, thereby contributing to a stable security environment.¹³

The air forces of Central and Eastern European countries, specifically the Visegrád countries in this context, reflect that institutional concepts rooted in the communist legacy, designed for Soviet/Russian fighter aircraft, remain active to varying degrees

¹³ MARK 2016.

within these defence institutions. The modernisation of Central and Eastern European air forces has been, and continues to be, pursued through the acquisition of fourth-generation multirole fighter aircraft. Upgrading and modernising their air forces with advanced multirole fighter jets to enhance defensive capabilities remains a priority for all four countries. This modernisation is essential for these countries to integrate effectively into NATO's collective defence framework, thereby further stabilising the region.¹⁴

While the air force plays a crucial role in maintaining stability, relying solely on air power is insufficient to address complex security challenges. A more comprehensive approach is required, incorporating ground forces and diplomatic efforts.

The outbreak of full-scale conflict between Russia and Ukraine has led to several incidents involving aerial and missile threats, as well as air defence systems, in the airspace of Central and Eastern European countries. In this context, it is essential to consider the hypothetical claim that some of these incidents were deliberate provocations by Russia against NATO or Ukraine. To effectively counter these challenges, Central and Eastern European countries must enhance their technical capabilities, develop response procedures and strategies, and take necessary military and diplomatic actions.¹⁵

The increased risk of conflicts between states and the renewed focus on the ability to wage large-scale conventional wars within Europe have reignited interest among European states in ground-based air defence systems. Since the end of the Cold War, European armed forces have grown accustomed to operating in permissive air environments. Significant investments in capabilities tailored to counterinsurgency campaigns, such as those in Afghanistan, have led to the atrophy of Europe's ground-based air defence systems. Even during the Cold War, less emphasis was placed on ground-based air defence compared to air forces, based on the assumption that NATO would maintain air superiority over Warsaw Pact forces. However, Europe's relatively limited inventory of air defence systems now faces increasing challenges due to the growing complexity of aerial threats.¹⁶

As a result, enhancing air and missile defence capabilities has once again become a priority on the agenda of NATO and its European partner states. However, significant gaps remain in terms of coverage and capabilities. Among these challenges is the fact that some alliance members, including the Visegrád countries, still operate outdated or even Soviet-era systems.¹⁷

Comparative analysis of the air forces of the Visegrád countries

Air Forces are a significant component of any military, as air capabilities are linked to successful operations that contribute to cooperation with all other branches of the armed forces. Military conflicts in recent decades have demonstrated that the air dimension of

¹⁴ YOUNG 2023.

¹⁵ BORNIO 2024.

¹⁶ TONG 2020.

¹⁷ Business Insider 2021.

contemporary operations remains vital. Security is a fundamental issue, and its funding must therefore be stable.¹⁸

Since 2014 – which is considered a significant milestone due to the annexation of Crimea by Russia – the defence budgets of European countries, including those of the Visegrád Group, have seen a noticeable increase. The defence budgets in the respective countries have grown as follows, calculated at 2015 prices and exchange rates: in Hungary, the budget increased from \$1.035 billion in 2014 to \$3.365 billion in 2024 (estimated), representing a growth of 225%. In the Czech Republic, it rose from \$1.683 billion in 2014 to \$4.567 billion in 2024 (estimated), an increase of 171%. In Slovakia, the budget grew from \$832 million in 2014 to \$2.118 billion in 2024 (estimated), showing a growth of 154%. In Poland, it increased from \$8.557 billion in 2014 to \$26.839 billion in 2024 (estimated), representing an increase of 213%. The ratio of defence spending to GDP also rose in these countries. In Hungary, it went from 0.86% in 2014 to 2.11% in 2024. In the Czech Republic, it increased from 0.94% in 2014 to 2.1% in 2024. In Slovakia, it grew from 0.98% in 2014 to 2.0% in 2024, while in Poland, it rose from 1.88% in 2014 to 4.12% in 2024.¹⁹

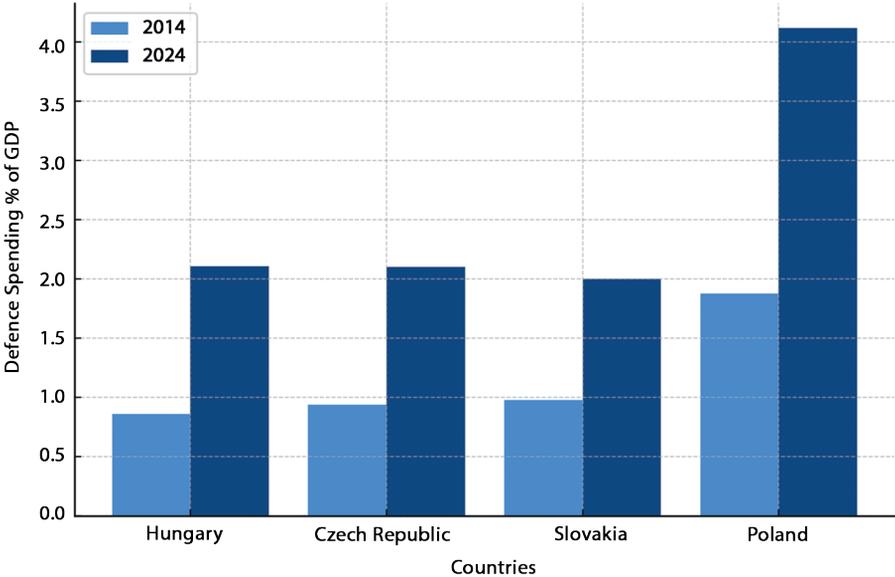


Figure 1: The GDP-proportional defence budgets of the Visegrád countries in comparison between 2014 and 2024

Source: NATO 2024

¹⁸ RAJCHEL-ZAŁĘSKI 2022.

¹⁹ NATO 2024.

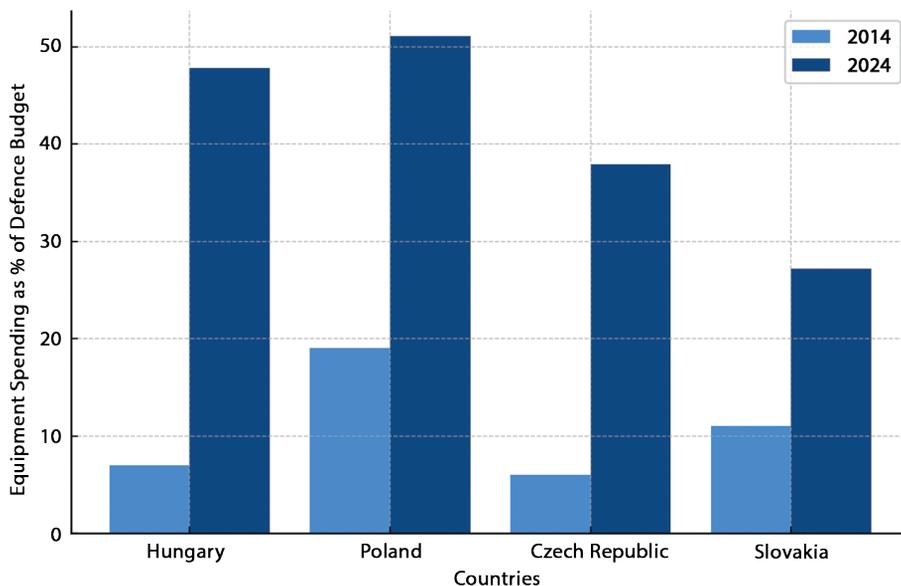


Figure 2: The proportion of defence expenditures allocated to equipment procurement by the Visegrád countries in 2014 and 2024

Source: NATO 2024

NATO has two important recommendations (expectations) for its member states: to allocate at least 2% of their GDP (Figure 1) to defence spending and to dedicate a minimum of 20% of the defence budget to equipment (Figure 2). While none of the examined countries met these criteria in 2014, by 2024, Hungary, Poland, Slovakia and the Czech Republic all surpassed NATO’s recommended minimum of 20% for equipment spending. Hungary and Poland were particularly notable, achieving ratios above and almost 50%, the Czech Republic with 37.9% and the Slovak Republic is also well above the recommendation by its share of 27.2%.

The Czech Republic published its latest security strategy in 2023. In this document, NATO and EU membership are identified as critically important for the country’s security, while Russia and the deteriorating international security environment are highlighted as the main threats to their nation. It also addresses issues related to cyber and information operations, as well as the challenges posed by China to the international order. Among the priorities for military modernisation are infantry fighting vehicles, self-propelled artillery, utility helicopters, transport aircraft, short-range air defence systems and uncrewed aerial vehicles (UAVs), among others. Additionally, Prague announced in 2023 its decision to acquire F-35 Lightning II aircraft²⁰ to replace its leased Gripen fleet. The defence-

²⁰ McNEIL 2024.

industrial base also includes development and manufacturing capabilities, particularly in small arms, vehicles, and training and light attack aircraft.²¹

Hungary published its National Security Strategy²² in April 2020 and its National Military Strategy²³ in June 2021. These documents reflect a deteriorating security environment characterised by great power competition. The 2021 Military Strategy emphasises the role of the air force and the importance of its development. Enhancing the air force enables improvements in the air defence, strike, aerial refuelling, reconnaissance and electronic warfare capabilities of tactical aircraft, as well as their deployable and ground support functions. Additionally, the strategy highlights the development of three airbases, as well as air defence and air command and control capabilities. These developments contribute to the air force's ability to perform air policing and air defence tasks to maintain the sovereignty of Hungarian and allied airspace, integrated into NATO's air command and control system. They also enhance the capacity to provide support for the operations of ground forces.

For the Republic of Poland, territorial defence and NATO membership are central pillars of the country's defence policy. The primary objective of the 2017–2032 defence concept is to prepare the armed forces to deter Russian aggression. Russia is characterised as a direct threat to Poland and the stability of the international order, a view that was further heightened by Russia's invasion of Ukraine in February 2022. Defending the Belarusian border has also become a key task for the Polish armed forces. Poland is one of the main European supporters of Ukraine, providing significant defence equipment, including armoured vehicles and anti-tank systems. Warsaw has increased defence spending to support modernisation projects. The technical modernisation plan for the period 2021–2035 was published in October 2019, extending the planning horizon from ten to fifteen years.²⁴ Among the modernisation efforts is the acquisition of the F-35A fighter aircraft, which is set to arrive in Poland in 2026.²⁵

As a NATO and EU Member State, Slovakia works closely with the Visegrád Group. Bratislava has signed an agreement to enable closer integration of air policing and air defence capabilities to stabilise security. In 2022, Slovakia signed a defence cooperation agreement with the United States, and under the Foreign Military Financing programme, resources were allocated to help the country replace some of the military equipment sent to Ukraine since the Russian invasion.²⁶ In addition to these efforts, Slovakia is also modernising both its air and ground forces.²⁷

²¹ Ministry of Foreign Affairs of the Czech Republic 2023.

²² Government Resolution 1163/2020 (IV. 21.).

²³ Government Resolution 1393/2021 (VI. 24.).

²⁴ Ministry of National Defence of the Republic of Poland 2024.

²⁵ ADAMOWSKI 2024.

²⁶ Ministry of Defence of the Slovak Republic 2024.

²⁷ SMISEK 2023.

Table 1: Active total military and air force personnel of the Visegrád Group

	Active military personnel (person)	Air Force (person)
Republic of Poland	164,100	18,850
Hungary	32,150	5,750
The Czech Republic	26,600	5,850
The Slovak Republic	12,800	4,550

Source: The International Institute for Strategic Studies 2024

Within the Visegrád Group, when considering only the active military personnel, the Polish Air Force stands out (see in Table 2). In addition to its personnel, the Polish Air Force operates 180 fixed-wing and 73 rotary-wing aircraft. However, some of its equipment has become outdated, including the MiG-29 fighter jets and Su-22 attack aircraft. Poland’s F-16 fleet is also aging. For this reason, Poland has taken significant steps toward modernisation, notably by purchasing 12 FA-50 fighter jets from South Korea.²⁸

Table 2: Aircraft inventory of the Visegrád countries

Country	Fixed wing aircraft	Rotary wing aircraft	Uncrewed aircraft systems
Republic of Poland	180	73*	24
	Fighter (FTR): 14	Utility: 8	Combat ISR: 24
	Fighter/Ground Attack (FGA): 74	Transport: 65	
	Airborne Early Warning and Control (AEW&C): 2		
	Transport (TPT): 51		
	Trainer (TRG): 40		
Hungary**	26	43	—
	Fighter/Ground Attack (FGA): 14	Attack: 8	
	Transport (TPT): 4	Utility: 25	
	Trainer (TRG): 8	Transport: 10	
The Czech Republic	52	52	—***
	Fighter/Ground Attack (FGA): 14	Attack: 14	
	Attack (ATK): 16	Utility: 5	
	Transport (TPT): 14	Transport: 33	
	Trainer (TRG): 8		

²⁸ OLECH 2024.

Country	Fixed wing aircraft	Rotary wing aircraft	Uncrewed aircraft systems
The Slovak Republic	15	18	–
	Fighter/Ground Attack (FGA): 2	Utility: 13	
	Transport (TPT): 5	Transport: 5	
	Trainer (TRG): 8		

* Poland’s Army possesses an additional 120 helicopters: attack 16, utility 67, transport 37.

** Hungary has received some aircraft since the last update of the Military Balance 2024 database: 1 piece of Embraer KC-390 transport and air-to-air refuelling aircraft (1 more on order); 2 pieces of Airbus Helicopters H225M medium utility helicopter (6 more on order).

*** The Czech Republic’s Army possesses an unknown number of UAVs (ScanEagle).

Source: The International Institute for Strategic Studies 2024

The Polish Air Force has invested in other areas as well, such as maritime patrol and airborne early warning and control (AEW&C) systems, which are crucial for border surveillance and enhancing air defence. In addition, Poland’s significant transport capacity (51 transport aircraft, including medium and light aircraft) and large rotary-wing fleet (65 transport helicopters, 8 multi-role helicopters and a significant number – 120 – attack, transport and utility helicopters at the Army) provide flexibility in both military and humanitarian operations. Furthermore, the country possesses a fleet of tactical intelligence, surveillance and reconnaissance (ISR) drones (the Turkish Bayraktar TB2), which align with modern warfare, meaning that both reconnaissance and combat operations increasingly rely on uncrewed systems.

Considering the size of its air force and its geopolitical location, Poland plays a critically important role in NATO’s collective defence, especially given its geographical proximity to Russia and the growing significance of the Baltic region. However, reliance on aging Soviet-era equipment presents a challenge, which Poland is addressing through gradual modernisation. According to Poland’s defence plans for 2032, these acquisitions should be based on even more rigorous data analysis than currently used, and proposed purchases should be verified through exercises and simulations, according to Poland’s defence forecast.²⁹

Based on the following table (Table 3), it is apparent that Poland, in addition to its existing significant air combat capabilities, has made substantial procurement related to its air force, with a considerable volume of orders placed. The country is purchasing additional fixed-wing and rotary-wing aircraft, uncrewed aerial systems, enhancing its air defence, and acquiring a significant quantity of munitions (missiles and bombs) necessary for its aircraft and air defence systems. The significant increase in the share of the defence budget allocated for procurement, as previously presented, is clearly reflected in these purchases.

The Hungarian Air Force shows significant differences in size and capability compared to the Polish Air Force, similarly to the Czech and Slovak Air Forces. The air force of Hungary is much closer in size and tactical assets to that of the Czech Republic, with

²⁹ Ministry of National Defence of the Republic of Poland 2024.

active air force personnel of 5,750 and a fleet consisting of 43 rotary-wing and 26 fixed-wing aircraft. According to the database of the International Institute for Strategic Studies (Military Balance +), similarly to the Czech Republic, Hungary has 14 Gripen fighter aircraft, which may soon be expanded to 18 according to the Hungarian Government³⁰ providing modern and adequate protection for the country and NATO allied countries' airspace. The Gripen aircraft sufficiently meet Hungary's defence needs, offering advanced flight and combat capabilities. Furthermore, Hungary's fleet of 14 JAS-39 C/D Gripens currently participates in air defence alongside Slovenia, Slovakia and Croatia, as well as in the Baltic Air Policing mission on a rotational basis.³¹

Hungary's air transport capacity is more limited, with only 5 transport aircraft, but it is supported by 25 utility and 10 transport helicopters, which ensure flexibility in various tasks. Similarly to Poland, Hungary has also started modernising its air force in line with NATO requirements, though its air force remains relatively modest in size overall.

Table 3: Recent and expected procurements of the Polish Air Force

Recipient	Supplier	Designation	Description	Weapon category	Order year	Number ordered	Delivery years
Poland	United Kingdom	AW-101-111	ASW helicopter	Aircraft	2019	4	2023
Poland	United States	F-35A	FGA aircraft	Aircraft	2020	32	Not yet completed
Poland	United States	C-130H Hercules	Transport aircraft	Aircraft	2021	5	Not yet completed
Poland	United States	S-70L Black Hawk	Transport helicopter	Aircraft	2021	4	Not yet completed
Poland	Türkiye	Bayraktar TB2	Armed UAV	Aircraft	2021	24	Not yet completed
Poland	Italy	M-346 Master	Trainer/ combat aircraft	Aircraft	2021?	4	2022
Poland	United Kingdom	CAMM	SAM	Missiles	2022?	750?	Not yet completed
Poland	United States	AH-64E Apache	Combat helicopter	Aircraft	2022?	96?	Not yet completed
Poland	South Korea	FA-50 Block 20	FGA aircraft	Aircraft	2022	36	Not yet completed
Poland	United States	MQ-9 UAV	UAV	Aircraft	2022	2?	Not yet completed
Poland	United Kingdom	Brimstone	ASM	Missiles	2022?	130?	Not yet completed
Poland	South Korea	FA-50	FGA aircraft	Aircraft	2022	12	2023

³⁰ Government of Hungary 2024.

³¹ BARANYAI 2024.

Recipient	Supplier	Designation	Description	Weapon category	Order year	Number ordered	Delivery years
Poland	United States	Javelin ATM	Anti-tank missile	Missiles	2023	500?	Not yet completed
Poland	United States	AH-64E Apache	Combat helicopter	Aircraft	2023	8	Not yet completed
Poland	Sweden	Saab 340AEW	AEW&C aircraft	Aircraft	2023	2	Not yet completed
Poland	United States	MQ-9 UAV	UAV	Aircraft	2023?		Not yet completed
Poland	United States	Patriot-3 LTAMDS SAMS	SAM system	Air defence systems	2023	12	Not yet completed
Poland	United Kingdom	CAMM-ER	SAM	Missiles	2023	1,000?	Not yet completed
Poland	United States	MIM-104 PAC-3 MSE	ABM missile	Missiles	2023	644?	Not yet completed
Poland	Italy	AW-101	Transport helicopter	Aircraft	2023?	22?	Not yet completed
Poland	United States	AGM-114 Hellfire II	Anti-tank missile/ASM	Missiles	2023	800?	Not yet completed
Poland	United States	AGM-179 JAGM	Anti-tank missile/ASM	Missiles	2023	460?	Not yet completed
Poland	United States	AGM-114 Hellfire II	Anti-tank missile/ASM	Missiles	2023	1,844?	Not yet completed
Poland	United States	S-70L Black Hawk	Transport helicopter	Aircraft	2023?	32?	Not yet completed
Poland	United Kingdom	CAMM-MR	SAM	Missiles	2023	300?	Not yet completed

Source: SIPRI 2025

In case of Hungary (Table 4), a significant procurement of multi-role helicopters is observed, along with the development and introduction of airlift and air-to-air refuelling capabilities, purchase of air defence systems and ammunition procurement. While the purchase of uncrewed aerial systems is not on the list, loitering munition appear among the incoming items. Although there have been discussions about expanding the Gripen fleet for some time, no orders have been placed yet. However, the arrival of next-generation jet trainer aircraft (L-39NG) is considered a significant expansion, marking progress both in training and in light air support and reconnaissance capabilities.

The Czech Republic, similarly to Hungary, possesses a relatively balanced air force with an active personnel of 5,850 and a fleet comprising 52 fixed-wing aircraft and 52 helicopters. The country modernised its tactical aircraft inventory with 14 Gripen jets, which provide a capable and versatile defence platform for protecting the nation's airspace.

In terms of transport capabilities, the Czech Republic operates a fleet of 14 transport aircraft, enabling support for both military and humanitarian operations. The rotary-wing component includes 14 attack helicopters and altogether 38 transport and utility helicopters, offering flexibility for various missions. The Czech Republic has also invested in ground-based air defence equipment, further enhancing the country's security guarantees.

Table 4: Recent and expected procurements of the Hungarian Air Force

Recipient	Supplier	Designation	Description	Weapon category	Order year	Number ordered	Delivery years
Hungary	Germany	EC-145	Light helicopter	Aircraft	2018	20	2021
Hungary	France	H-725 Caracal	Transport helicopter	Aircraft	2018	16	Not yet completed
Hungary	Brazil	C-390	Transport aircraft	Aircraft	2020	2	Not yet completed
Hungary	Norway	NASAMS-2	SAM system	Air defence systems	2020	7?	Not yet completed
Hungary	United States	AIM-120C AMRAAM	BVRAAM	Missiles	2020	180?	Not yet completed
Hungary	Czech Republic	L-39NG	Trainer/combat aircraft	Aircraft	2022	12	Not yet completed
Hungary	United States	AMRAAM-ER	SAM	Missiles	2022?	60?	Not yet completed
Hungary	Israel	Hero-30	Loitering munition	Missiles	2023		Not yet completed

Source: SIPRI 2025

Significant procurements, capability development and expansion can also be observed in the Czech Republic based on the above data (Table 5). A large number of aircraft, air defence systems, and munitions are being acquired. Notably, the extensive procurement of 5th-generation tactical aircraft (F-35A) and the introduction of air command and control capabilities stand out. The number of F-35A aircraft ordered is only one squadron fewer than Poland's, marking a significant "leap forward" as few countries of similar size possess such a modern and substantial fleet. The Russian–Ukrainian conflict has highlighted the utility of man-portable air defence systems (MANPADS), leading to an expansion of the 2018 order in 2023.

Slovakia's air force can be considered the smallest among the four Visegrád countries, with an active air force personnel of just 4,400 and a fleet consisting of 15 fixed-wing aircraft and 18 helicopters, according to the latest data of the International Institute for Strategic Studies (Military Balance +). Like the other Visegrád countries, Slovakia has also begun modernising its air force with the procurement of F-16s intended to replace

its aging Soviet-era fighter jets.³² However, Slovakia currently operates only two such (F-16) fighters, which number is modest both subregionally and regionally. Slovakia's air transport capabilities are also limited, with only five transport aircraft (two medium and three light), constraining its airlift capacity.

Based on the data, Slovakia's current air defence cannot be considered adequate by international standards, and the country does not operate an integrated air defence system. This leaves Slovakia vulnerable during a period when the risk of air attacks is increasing.³³ Despite the limitations in its fleet and the relatively small active air force, Slovakia has sought to improve its rotary-wing capabilities with a fleet of 13 utility helicopters. However, the overall size of the Slovak Air Force remains limited, making it essential for the country to rely on NATO allies to strengthen its defence capabilities. In terms of its capabilities, Slovakia can no longer be considered a prominent international actor in the field of air defence. The Slovak Ministry of Defence has recognised this, partly due to the ongoing conflict in Ukraine, and has begun preparing plans for the procurement of modern air defence systems. Air defence is a vital and irreplaceable element of national security, but the process of building a modern and stronger Slovak air defence is still in its early stages. Air defence is critical for protecting the country's critical infrastructure and safeguarding manoeuvring ground forces, as confirmed by the conflict in Ukraine. This includes the development of unmanned aerial vehicles and new technologies in this domain.³⁴

Table 5: Recent and expected procurements of the Czech Air Force

Recipient	Supplier	Designation	Description	Weapon category	Order year	Number ordered	Delivery years
Czech Republic	Sweden	RBS-70	Portable SAM	Missiles	2018?	80?	2023
Czech Republic	Spain	C-295	Transport aircraft	Aircraft	2019	2	2021
Czech Republic	United States	UH-1Y	Helicopter	Aircraft	2019	8	Not yet completed
Czech Republic	United States	AH-1Z Viper	Combat helicopter	Aircraft	2019	4	2023
Czech Republic	Israel	Python-5	BVRAAM	Missiles	2020?	200?	Not yet completed
Czech Republic	Israel	SPYDER-MR	SAM system	Air defence systems	2021	4	Not yet completed
Czech Republic	Israel	I-Derby	BVRAAM/SAM	Missiles	2021	200?	Not yet completed
Czech Republic	United States	AGM-114 Hellfire II	Anti-tank missile/ASM	Missiles	2021?	14?	2023
Czech Republic	United States	AH-1Z Viper	Combat helicopter	Aircraft	2022	6	Not yet completed

³² Reuters 2024.

³³ HARDMAN 2024.

³⁴ DÓKA 2023.

Recipient	Supplier	Designation	Description	Weapon category	Order year	Number ordered	Delivery years
Czech Republic	United States	UH-1Y	Helicopter	Aircraft	2022	2	Not yet completed
Czech Republic	Israel	Heron UAV	UAV	Aircraft	2022?	3	Not yet completed
Czech Republic	Brazil	C-390	Transport aircraft	Aircraft	2023?	2	Not yet completed
Czech Republic	United States	F-35A	FGA aircraft	Aircraft	2023?	24	Not yet completed
Czech Republic	Sweden	RBS-70-3	Portable SAM	Missiles	2023	135	Not yet completed
Czech Republic	Israel	I-Derby-ER	BVRAAM	Missiles	2023	48	Not yet completed

Source: SIPRI 2025

Slovakia's procurements (Table 6) are the most modest among the four countries, with a clear focus on air defence. The ordered 4.5-generation fighter jets are considered relatively advanced, and the weapons to be acquired alongside them are intended to ensure the protection of the country's airspace. Additionally, the list includes surface-based air defence systems, and similarly to the Czech acquisitions – likely drawn from lessons of the Russia–Ukraine war – MANPAD systems are also being procured alongside “gun-based” air defence systems.

The armaments of the air forces listed above show that the Visegrád countries possess varying capabilities and levels of modernisation within the Central and Eastern European region. Poland stands out as having the largest and most diverse air force among the four countries, but a portion of its equipment is aging, necessitating ongoing modernisation efforts. Even in 2016, during the NATO Summit in Warsaw, deterrence and collective defence were given renewed emphasis, with Poland receiving special attention as a geostrategically prioritised location on the axis of NATO operations' sustainability in the region.³⁵

In contrast, Slovakia has the smallest and least capable air force for providing adequate protection for its own territory and the region. However, it has begun procuring modern F-16 fighter jets to enhance its defensive capabilities. The Czech Republic and Hungary share similar attributes in terms of active military personnel and the size and capabilities of their fleets, relying on modern Gripen fighters acquired through recent procurements, and they maintain balanced air force structures. While all four countries have initiated modernisation efforts for their fleets to meet NATO standards and strengthen regional security – thereby ensuring stability for their countries and the region as a whole – they still face challenges related to their reliance on aging Soviet-era equipment.

³⁵ RAJCHEL–ZALĘSKI 2022.

Table 6: Recent and expected procurements of the Slovak Air Force

Recipient	Supplier	Designation	Description	Weapon category	Order year	Number ordered	Delivery years
Slovakia	United States	AIM-9X	BVRAAM	Missiles	2018	98	Not yet completed
Slovakia	United States	F-16V Viper	FGA aircraft	Aircraft	2018	14	Not yet completed
Slovakia	United States	AIM-120C AMRAAM	BVRAAM	Missiles	2018	30	Not yet completed
Slovakia	Israel	Barak-MX Land	SAM system	Air defence systems	2023?	1	Not yet completed
Slovakia	Poland	Piorun	Portable SAM	Missiles	2023?	180?	Not yet completed
Slovakia	Germany	Skyshield 35	AA gun system	Air defence systems	2023	2	2023

Source: SIPRI 2025

Conclusions

The study focused on the four countries of the Visegrád Group within the Central and Eastern European region, emphasising the air force and its importance. In recent years, the Visegrád countries have warranted significant attention from a security perspective for several reasons. This period represents a critical time for the EU, NATO and the Visegrád countries, as they face unprecedented and simultaneous external challenges in the field of security.

During this period, significant developments occurred in the security cooperation of the Visegrád Group, including increased defence spending and enhanced collaboration with NATO. Additionally, the V4 countries experienced notable changes in their relations with neighbouring states, including Ukraine and Russia. These relationships are critical to regional security, and shifts in these dynamics have had, and continue to have, a substantial impact on the security and stability of the V4 countries.

Partly due to Russia’s full-scale invasion of Ukraine, NATO’s defence spending surged in 2024, with 19 of the alliance’s 32 member states achieving double-digit increases in their military budgets. According to the latest NATO military expenditure data, 23 member states will meet or exceed the 2% GDP target for defence spending this year, compared to just seven in 2022 and three in 2014.³⁶ The increased expenditures are clearly evident in the four Visegrád countries mentioned in the study, as they remain committed to modernising their fleets. They aim to replace aging Soviet-era fighter jets with new, more advanced tactical aircraft to ensure more effective air defence – an effort that is especially crucial during the current wartime period. This is particularly significant in the Central and Eastern European region, where three of the four V4 countries share borders with Ukraine.

³⁶ FIX-KAPP 2024.

In case of Hungary, the defence budget increased by 269.58%, Poland increased by 289.47%, while the Czech Republic and Slovakia increased their expenditure by 93.85% and 153.2%, respectively. These figures reflect the commitment of the Visegrád countries to strengthen their national security.

NATO's expectations of spending 2% of GDP on defence and at least 20% of the defence budget on equipment were benchmarks for all four countries. While none of the Visegrád countries met these targets in 2014, they almost all did by 2023. Poland and Hungary stand out for the significant resources they have devoted to modernisation, particularly in terms of procurement to NATO standards.

Poland has the largest and most diverse air force, with 194 fixed-wing and 214 rotary-wing aircraft and 24 unmanned systems. In a modernisation drive, Poland has started to acquire F-35 fighter jets and modern helicopters, while gradually replacing old Soviet-made equipment. Poland's size and geopolitical position make it a key player in the defence of NATO's eastern flank, particularly because of its proximity to Russia.

Hungary has a more modest air force, with 34 fixed-wing and 35 rotary-wing aircraft. The modernisation of Gripen fighters and utility and attack helicopters will ensure the country's defence and enable NATO integration. Although the transport capacity is limited – only 12 aircraft are available – the modernisation of the Hungarian Air Force is ongoing and aims at the effective protection of national and allied airspace.

The Czech Air Force consists of 52 fixed-wing and 44 rotary-wing aircraft. The country has recently begun procurement of the F-35 fighter aircraft, which represent a significant step forward in modernisation. The Czech Republic is strongly focusing on the development of air defence systems and plays an important role in support of NATO operations, especially in transport and air support missions.

Slovakia has the smallest air force of the four countries, with only 15 fixed-wing and 18 rotary-wing aircraft. Although the country has started to replace obsolete Soviet fighters with modern F-16s, its air capacity remains modest. The need to improve Slovakia's air defence was made clear by the conflict in Ukraine, but the necessary procurement and development is still in the early stages.

Although there is no active air defence cooperation between the Visegrád countries, current security threats are perceived in a similar way. One of the ways to guarantee security in the region is to modernise air defences, which play a crucial role in maintaining stability. The development of the air forces of the Visegrád countries is a decisive factor for security in Central and Eastern Europe, not only at national level, but also at regional and allied level. There is also a unique security complex in Central and Eastern Europe that is separate from the wider European security framework. This complex was characterised by specific dynamics and interactions between the states of the region, influenced by historical, political and social factors.³⁷

³⁷ ALEXANDRESCU 2022.

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National and International Perspectives of the Hungarian Ground-Based Air Defence Forces, Part 3

Potential Ways Forward in Developing Air and Missile Defence Capabilities

Daniel PASSBACH¹ 

Expanding on the conclusions of the first two parts in this series, several aspects of the further capability management process are examined in this article. After having assessed that the recent procurement decisions and the first steps towards a true capability have been prudently taken by the Hungarian Defence Forces, possible options for the way forward are considered and potential future steps proposed. The path towards a solid GBAD capability has been taken; now it will be essential to stay on track and prepare consequent and reasonable steps for the short- and medium-term future.

Keywords: Hungarian Defence Forces, ground-based air defence, DOTMLPFI, Army Organic Air Defence, NASAMS, interoperability

“It is not a shame to learn from those who know more, it is a shame to bind oneself in ignorance and not learn.”
Miklós Zrínyi

The patron of the Hungarian Defence Forces’ (HDF) force development programme, Miklós Zrínyi, understood that a complex system to strengthen defence capabilities is necessary. Amongst other things, he became famous by using the terrain to his troops’ advantage.² Nowadays, this can be viewed metaphorically, when it is decisive to make use of the political and economic terrain, hence the given circumstances, to achieve one’s strategic goal.

Consequently following Zrínyi’s ideas, the complete modernisation of the HDF during recent and current years, including procurement of equipment and reshaping the force

¹ LtCol (GS) German Air Force, German Defence Attaché to Hungary, German Embassy, Budapest, e-mail: daniel@passbach.de

² PADÁNYI–ONDRÉK 2023.

structure, has been conducted in accordance with NATO requirements and with the strategic objectives of NATO and the EU.

Next to this finding, I have carved out in the first two parts of this publication series that the current modernisation measures imply that Hungary will join the group of NATO's most advanced air defence nations. However, the path from the important step of contracting a procurement towards finally achieving an adequate capability could take longer than some external, non-military observers might suspect. In this following article, I will propose options for possible ways forward in the various aspects that were closely looked at in the previous considerations. Eventually, I will recommend first thinkable steps for the near future.

DOTMLPFI as the most suitable methodology framework

In establishing and managing military capabilities, the most structured way is to apply the DOTMLPFI³ methodology. To analyse capability development issues comprehensively, the full spectrum of DOTMLPFI would have to be considered. A state-of-the-art weapon system without adequate infrastructure or properly trained personnel does not represent a true capability.

Due to the volume restrictions of this article, my analysis cannot and does not intend to provide a thorough analysis of all letters. Therefore, only selected aspects of DOTMLPFI in context with future options will be touched upon. For properly analysing the “P” (personnel), a holistic scrutiny of Hungary's demography and labour market would be necessary. The “M” (material) has already been reflected in detail in several other sections of this article series. The “F” (facilities/ infrastructure/logistics) always represents a big challenge in capability processes; it would be a full separate topic for analysis and depends in practical terms on the respective national planning processes. The “L” (leadership and education) will briefly be dealt with in the “implications and prerequisites” section of this text, where I will address leadership and cultural aspects as well.

Doctrine

Assuming that deterrence and defence operations will always work in a multinational contingent together with allies, it will be crucial to synchronise the HDF doctrines as much as possible with those of allied nations. This will create numerous synergy effects and will increase flexibility and responsiveness if short notice action is necessary.

From a ground-based air defence (GBAD) perspective, extensive lessons learned from the Russian war in Ukraine can be drawn for almost the full spectrum of Air and Missile Defence (AMD) operations. These will have to be implemented into the next generation of doctrinal documents, harmonised amongst allied nations. The group of user nations for a modern weapon system has to establish close connections and to interact in terms of

³ DOTMLPFI: Doctrine, Organisation, Training, Material, Leadership, Personnel, Facilities, Interoperability.

doctrines for weapon employment or best practices in logistical procedures. Many modern systems that build the backbone of NATO's Integrated Air and Missile Defence System (NATINAMDS) are currently deployed in Ukraine or in the deterrence posture at NATO's Eastern flank; it is obvious that this will provide numerous valuable insights.

For the HDF it is now important to establish the doctrinal portfolio for the new capabilities. The overarching procedures for the SAMOC (Surface-to-Air Missile Operations Centre) will continuously be synchronised with Germany as an experienced user nation. But eventually, the Hungarian GBAD community will have the task to set up their internal doctrinal foundation. This includes a wide spectrum of Command and Control (C2) options and how a GBAD contingent can be composed under the SAMOC umbrella. It will also be necessary to define the options of integrating with a national or multinational higher C2 echelon.

Another vital issue will be the procedural Air Force GBAD and Land Forces' Army Organic Air Defence (AOAD) coordination. This is a direct consequence of the formal decision to develop and procure a new short range air defence (SHORAD) capability – based on the Skyranger 30 system and mounted on a Lynx KF41 – for the Hungarian land forces' units.⁴

The biggest challenge appears to be the NASAMS (Norwegian Advanced Surface-to-Air Missile System) doctrines. Although the user community is widespread amongst allies, albeit with different versions or system configurations, it has been difficult to find a close partner relation that could also support in establishing the main procedures. This comprises inter alia standing operating procedures (SOP), firing doctrines, training documents, technical procedures and further unit generated plans for the new weapon system.

Organisation

Regarding the organisation, the first task has been to fill the new regiment structure in Győr with life after the arrival of the first NASAMS systems. Next to continuously reviewing if the applied hierarchy and personnel tables will match the actual needs, it is essential to efficiently distribute the valuable human resources to the variety of new tasks. Naturally, the same personnel are dealing with the very demanding transition phase from operating the Soviet-era SA-6 to the state-of-the-art NASAMS. However, the fact that modern systems such as SAMOC and NASAMS with a high degree of automation require fewer personnel than the less sophisticated legacy systems generally helps to keep the to-be-filled personnel tables lean in times of demographic decline.

Assuming that around the Skyranger system, potentially supported by man-portable air defence systems (MANPADs) and anti-aircraft artillery (AAA) elements, a real organic air defence capability will be established in the Hungarian Land Forces, one of the first steps after the final procurement decision will have to be organisational planning.

⁴ The procurement decision for the Skyranger 30 has been taken by the Hungarian Government in December 2023. Cf. Europäische Sicherheit & Technik 2023.

Since this capability does currently not exist within the HDF, new units and force elements will have to be set up and filled with life in terms of capable and trained soldiers.

For organisational long-term considerations, it will be useful to keep the future option of integrating Hungarian force elements into multinational structures in mind. Be it a multinational air group or a true bi- or trilateral integration of air defence units, the maximum degree of flexibility for international embedment should be maintained.

Training as one of the key factors

Modern air defence systems require high training standards in technology and procedures to avoid serious unintentional incidents as the downing of civilian flights.⁵ Thus, after finding appropriate personnel in quantity and quality from the civilian labour market, the provision of properly trained military specialists will be a major challenge as well. This applies particularly to complex topics as air defence systems. For individual training, the former experienced SA-6 workforce represents a solid basis for transferring their knowledge into modern state-of-the-art proficiencies which are mandatory for operating and maintaining SAMOC and NASAMS.

Initial training in both SAMOC and NASAMS is provided by the industry manufacturers of both systems.⁶ But obviously, proper professional military training means much more than knowing which button to press or when and which routine maintenance to conduct in a given time interval. For the SAMOC level, just plugging in sensors and effectors is certainly not enough. The professional operating staff in the SAMOC and NASAMS systems must be able to recognise possibilities and limitations, evaluate them and act on this basis in a task-focused direction.

Internal SAMOC training – force operations, engagement operations and technical issues – will be guaranteed by the more experienced personnel within the MH Dániely Tibor 205th Air Defence Missile Regiment. This follows the concept of training the future trainers in the first step. However, further keeping up the good cooperation with the German Air Force's SAM Wing 1 as well as the conduct of common exercises will be crucial for ensuring professionalism in both countries and will create numerous synergies.

Ideally, the NASAMS training would follow a similar approach by first acquiring the introduction and the general training from the industry, then upskilling the future trainers by partner nations' experience and further training steps. Even though NLD is operating an older NASAMS version and LTU is also a relatively new user, continuous exchange with other user nations will help in overcoming common challenges in handling the weapon system.

Next to the individual proficiency, the unit- and formation-based training has to be intensified in the next step. After having completed all national accreditation and certification steps, further exercise participation with SAMOC and NASAMS contingent, e.g. during "Ramstein Legacy" (RALY) or "Joint Project Optic Windmill" (JPOW), should

⁵ Flights MH-17 in July 2020 in Ukraine and UIA 752 in January 2020 in Iran are prominent examples.

⁶ Expert discussion in MH Dániely Tibor 205th Air Defence Missile Regiment, 14 November 2022.

be continuously envisaged to test interoperability and to train the GBAD specialists within a combined environment. In parallel, periodical exercises and interoperability tests should be conducted in conjunction with the Hungarian Air C2 forces to train the connection and communication with the Hungarian Control and Reporting Centre (CRC) in Veszprém and with higher echelons.

In order to prepare for expectable NATO operational evaluations a wider spectrum than pure tactical air defence training must be covered. Weapon system operations, connectivity, force protection and further skills entail connecting various individual capabilities to an overall capable mission module.

Multinational training and exercise participation can offer promising perspectives for future operations. If e.g. the German AMD forces continuously invest a part of their scarce training capacities into fostering the new Hungarian capabilities, then this will pay off in the medium term. After a certain level of proficiency with the new equipment has been achieved as well as formal and legal prerequisites have been sorted, the participation of Hungarian SAMOC specialists in NATO enhanced Vigilance Activities (eVA) mission modules like the German temporary assignments in Slovakia or in Poland⁷ is thinkable. These capacities could be provided in return for the arranged training support and would finally lead to a classical win-win situation.

Having hopefully gained some advantages from prudent multinational air defence cooperation via formats as Modular GBAD⁸ and ESSI,⁹ a long-term goal could be the establishment of a true European GBAD training facility, under whose auspices common training will be conducted and air defence tactics as well as doctrines will be harmonised amongst the participating nations.

Interoperability

As assessed in part 2 of my article series,¹⁰ the future Hungarian GBAD system composition offers widespread options and provides perfect prerequisites for interoperability and interconnectivity. Based on this technological ability, the forces' capabilities to flexibly play with the C2 and system components will have to be enhanced. Interoperability checks within bilateral cooperation frameworks could serve as a starting point. However, participation in big multinational exercises as RALY or JPOW surely offers the best opportunities to explore possibilities and limitations. Continuously checking and synchronising interoperability issues and standards will be key and set the path towards future integration of the Hungarian GBAD forces into multinational contingents and formations.

⁷ See: <https://www.bundeswehr.de/de/auftrag/einsaetze/missionen/abgeschlossene-einsaetze-der-bundeswehr/enhanced-vigilance-activities-slowakei>; <https://www.bundeswehr.de/de/auftrag/einsaetze/missionen/abgeschlossene-einsaetze-der-bundeswehr/enhanced-vigilance-activities-eva-polen>

⁸ NATO's Modular GBAD High Visibility Project strives for a modular GBAD solution responding to air threats along the entire very short, short and medium range spectrum.

⁹ The European Sky Shield Initiative (ESSI) aims at creating a powerful air defence posture through joint acquisition of air defence equipment and missiles.

¹⁰ PASSBACH 2024b: 57–58.

After this brief DOTMLPFI consideration, I will try to merge some thoughts and options for ways forward in the different AMD capability areas. The national foundations in Hungary were laid by procuring modern, capable state-of-the-art hardware as part of the Zrínyi Programme. Now it will be the time for the HDF to build up on this solid backbone and develop the AMD capabilities further in order to become one of the most advanced air defence nations within NATO and EU. Based on the analysis above, I will discuss selected aspects of the HDF's emerging AOAD and AMD potential in the following sections.

Renaissance of the Army Organic Air Defence

The decision to swiftly build up a true AOAD capability by procuring a new SHORAD system had consequently been taken in parallel to the publication process of the first two articles of my publication series. During the negotiations of synchronising the German and Hungarian requirements and while working on a common basis to procure the Skyranger 30 system bilaterally – or even together with Denmark as the third partner – the Hungarian Government has decided to sign a direct contract with the manufacturer Rheinmetall instead of a joint procurement under the ESSI umbrella. This rather surprising move will hopefully not significantly limit the possibilities for close cooperation in logistical support and further common arrangements amongst user nations. There is still sufficient room to make use of synergies in the areas of training, maintenance and further exchange within the group of Skyranger 30 user nations.

According to the Hungarian implementation of the NATO Defence Planning Process (NDPP), currently air cover for an Infantry Brigade is provided with a stronger MISTRAL battery, provided by the Air Force units. In a few years' time, the NDPP requirements should be fulfilled with the newly procured AOAD system. The Skyranger capability development will perfectly serve this aim as well as the intended timelines.

Further options to upgrade the AOAD capabilities

When examining further opportunities to enhance the AOAD capability product-wise, it becomes clear that various commercial off-the-shelf (COTS) or military off-the-shelf (MOTS)¹¹ solutions are available. With the aspiration of covering the full VSHORAD and SHORAD spectrum, including Unmanned Aerial Systems (UAS) as well as “low, slow and small” targets (LSS),¹² the most promising approach will always be a prudent mix of a gun, presumably applying air burst ammunition, a capable SHORAD missile and – maybe as a future perspective – a viable energy weaponisation, e.g. a High Energy

¹¹ COTS and MOTS describe products or weapon systems that are available on the market and can be used without further adaptation or customisation.

¹² The so-called LSS (low, slow and small) target threat of micro drones and mini UASs are even available on the civil market and can be converted into weapons by self-construction.

Laser (HEL). Complemented by a suitable sensor solution and a fully interoperable C2 element, this would represent a true 21st century configuration. Additional effector technology based on Radio Frequency (RF) Jamming and High-Power Microwave (HPM) could be surveyed regarding the desired capability for countering UAS (C-UAS).

During the above DOTMLPFI consideration it became obvious that it takes much more to develop a capability than to acquire a technical weapon system solution only. Therefore, planning to incorporate this SHORAD/VSHORAD/C-UAS capability into the Hungarian Land Forces *inter alia* implies drafting of doctrines, pioneering work in terms of organisational structures and immense training requirements. Due to the previously outlined historical reasons,¹³ my assumption is that the Hungarian Land Forces currently have only rudimentary air defence competency left in their brigades. Hence establishing appropriate structures and qualification build-up will have to accompany the difficult transition phase until achieving Initial Operating Capability (IOC) or FOC of the AOAD elements.

Cross-domain and multinational thinking as the key to success

Based on the lessons learned from recent conflicts, instead of re-thinking an Air Force based option, the integration of a new SHORAD capability into the Hungarian Land Forces should be the preferred option. The Hungarian Air Force, with their available competence in air defence matters, will yet have to support the “training the trainers” of the land forces. Consequently, the training and competence-regaining process should also be discussed in the bi- or multinational framework, since Germany and other potential partner nations like Denmark will face similar challenges.

Not only the immediate operating staff will have to reconsider air defence thinking, but also the joint and land force commanders on various levels. Respecting the needs and specifics of organic air defence elements requires a new philosophy and demands awareness for thorough coordination with the respective air force authorities. Proper liaison elements to air force GBAD units and Air C2 will have to be established. Finally, regular training and exercise activities have to be conducted in a joint environment together with Hungarian Air Force GBAD units. Training the interfaces between the warfighting domains in peacetime is essential for understanding the specific needs and different cultures better when it comes to multi-domain NATO assignments and operations.

I deem it very important to discuss possible training and exercise approaches in the early stage of the capability development process. It has to be evaluated if a separate training institution for the Hungarian land brigades should be established or if a national air defence training element, comprising both land and air forces’ training, could be the more efficient solution.

¹³ PASSBACH 2024b: 59.

And, along my previous line of argumentation, these considerations should not only take place from a national perspective, but also in the multinational framework to identify medium term synergies. Eventually, the idea of a multinational AOAD training centre, preferably integrated into or connected to the above mentioned European GBAD training facility, should be pursued under the umbrella of ESSI.

Air and Missile Defence capabilities in the Hungarian Air Force

Considering the AMD elements within the organisational structure of Air Force units, the SAMOC cooperation with Germany should be intensified to further enhance the experience and proficiency of the Hungarian operators. This will offer the perspective of Hungarian participation in AMD Task Force (AMD TF) contingents compared to the aforementioned eVA missions. In parallel, a solid basis for cooperation with one or more NASAMS user nations should be established. Without the support of experienced users, it will be a huge challenge to meet the NATO requirements in time. The capability development of the NASAMS units across the full DOTMLPFI spectrum must be addressed with high priority, because in the currently evolving security environment the assignment in the NDPP context could potentially have to be adopted rather earlier than later.

As previously recommended, exercise participation with SAMOC and NASAMS elements will be the central key to future interoperability, proficiency and leadership education. Due to the excellent interoperability characteristics of both systems, there is a high degree of flexibility when setting up an exercise contingent consisting of different weapon systems or even single elements of sensor-effector configurations.

The decision for setting up an AOAD capability with new SHORAD forces in the HDF will not only affect the Hungarian Land Forces units. Also from an Air Force perspective, the GBAD C2 concepts will have to be reviewed. The operational interfaces to the AOAD as well as procedures for air space management and deconfliction must be established in connection with the higher echelon of the Hungarian Air C2 elements. In all these considerations, making use of 21st century solutions – e.g. virtual training options – will facilitate a quick development of the aspired capabilities.

Taking a further future perspective, the Hungarian Air Force and the subject matter experts within the regiment in Győr will have to be prepared to integrate upper layer missile defence capabilities in the long term. This is consistent by the mere fact that the SAMOC platform serves as the central AMD C2 element. However, first steps as sensor-effector sharing in a multinational context, potentially through ESSI, are not to be expected from the HDF prior to the next decade though.

Implications and prerequisites – Towards a new leadership culture?

Basically, the HDF are well suited to act as a capable partner in the multinational GBAD sector. On the other hand, the pursuit of far-reaching multinational cooperation would

require a further shift towards a new leadership style and a specific military culture in the face of not completely adapted structures and doctrines, remaining primarily from the Soviet era during the Cold War. One decisive, central postulate of the HDF transformation – as also extracted from the NMS 2021 – is to renew the organisational structure and the C2 system in a way that a faster and more flexible chain of command will provide bigger operational freedom for subordinated commanders.¹⁴ Thus, the path from the outdated, but still existing leadership style to a task-orientated approach in accordance with the mission command philosophy has to be taken at all levels of command.¹⁵

Some military leaders argue that new technologies and weapon systems automatically lead to a mission command culture. I clearly disagree. From my experience, mission command is primarily about the military leader's head and heart and is therefore the catalyst within the implementation of new weapon systems. Several authors explicitly support the approach for a new leadership style in the HDF with the reduction of authority to the lowest possible level. Remarkably, this is assessed to be the “opposite trend of the last thirty years”.¹⁶ Implementing a cultural change should primarily be an immediate consequence of NATO membership, which results in the associated necessity to fulfil Alliance tasks and to cooperate with allies. Undeniably, the change of the whole culture in a major organisation takes time and requires a conscious, bottom-up learning process, including all levels of command and applying values-based education and training.¹⁷ Eventually though, by implementing the mission-oriented approach to leadership, the individual space for manoeuvre will increase for commanders on all levels and decision-making processes will be accelerated.

Multinational training, exercises and operations offer the opportunity of incorporating cultural experiences gained amidst the international environment into the own organisation. To process these experiences most effectively, it is vital to firstly apply a common thinking and naturally a common language to ensure effective communication.¹⁸ Assessed on my multinational experience during the recent years, the English language must be the norm in the everyday work of allied militaries. When referring to NATO processes, the relevant terms should be used as standard phrases and acronyms in their original English form and not be translated unnecessarily. Presumably the reluctance to use the English language in more areas of the HDF is partly a generation issue and will automatically disperse in the medium term. Still the recommendation must be to start with this cultural change as soon as possible – and this analysis does not only apply for Hungary, but also for Germany and more European armed forces as well.

¹⁴ PASSBACH 2024a: 41.

¹⁵ Presentation on the reorganisation of the HDF at Ludovika by the Commander of the Force Modernisation and Transformation Command, Major General László Sticz, 14 October 2022.

¹⁶ TAKÁCS et al. 2021: 42.

¹⁷ SZABÓNÉ SZABÓ 2021: 77.

¹⁸ CZEGLÉDI 2021: 79.

Multinational military cooperation and potential spillover effects

I have previously deduced several times in my article series that a clear commitment to more multilateralism and integration will be key to contribute to strategic convergence within NATO and EU. For Hungary, the initial steps of stating this in its central conceptual documents as well as a credible force development have been taken or initiated. The HDF with its immense material investments into an adequate modern and interoperable air defence capability can still be considered of having played a pioneering role within Eastern Europe in phasing out the old Soviet systems and swiftly replacing them with modern interoperable technology. Recently, numerous other nations were forced to take similar steps in the face of the Russian aggression against Ukraine.

But even on the highest political level, Hungary should always be seen as a trustworthy and reliable partner within its alliances. Due to the current political narratives and atmosphere at the governmental level in Budapest and Brussels, justified concerns cannot be dismissed. This would be even more unfortunate as the currently valid Hungarian strategic national documents demonstrate a clear commitment towards NATO and EU. Furthermore, all associated actions like exercise and operational contributions to both alliances clearly prove that the HDF acts as a reliable partner in the military sphere, together with its NATO and EU allies.

Closing this short political sidestep, I see two sides of the medal and two ways to draw an adequate conclusion in this matter: On the one hand, it would be regrettable if allied armed forces – in this case the HDF – would have to suffer from disputes on the highest political levels. However, it is obvious that a “relaxed normality” cannot be pretended in the field of military cooperation whilst intergovernmental relations are massively strained. On the other hand, continued fruitful collaboration in defence matters can assist in normalising the crosscutting relations between governments. It is not only my hope that the possibilities of multinational cooperation will not be too much constrained by the current political situation. On the contrary, trustful military cooperation between allied nations can ultimately create positive strategic implications and contribute to an overall political détente.

Conclusion

On my path through the main questions of my article series so far, I have taken several short “intellectual sidesteps”. They would all be worth to be analysed separately and in a more comprehensive manner. All these little pieces of the big puzzle show the overall complexity of the topic. At this point, I can still confirm my central hypothesis that the HDF are on track to becoming one of the most capable GBAD nations in Europe and in NATO. The prudent procurement steps, the acquired system specifications and interoperability characteristics form solid preconditions for excellent future capabilities. The current status quo, the intended capability development and the multifaceted future perspectives in AMD matters are promising; all those elements perfectly serve both Hungarian national

security ambitions as well as the respective NATO requirements in setting up an enhanced and credible deterrence and defence capability against aerial threats.

It will be decisive from a national Hungarian perspective how successfully this “treasure hunt through the DOTMLPFI jungle of capability management” will be performed. The persistent pursuit of various opportunities for multinational integration within the field of AMD to further develop the HDF’s capabilities will play a pivotal role. It will eventually create significant synergies for future alliance operations.

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Supporting the Development of Hungary's National Resilience with Special Operations Forces

Sándor TAMÁS¹ 

The ever-changing security environment and the experience of the war in Ukraine not only underlined the importance of a strong defence force but also highlighted the need for effective national resilience. The development of national resilience, the building and operation of the system cannot be imagined without the support of the Hungarian Defence Forces. At the same time, the use of conventional military capabilities takes resources away from training and preparation that can be highly photogenic in the execution of the basic tasks of the force. At the same time, special operations forces can be an appropriate solution for building national resilience. Effective national resilience can also be a deterrent to conventional armed conflict. Recent legislative changes will make the policy-making process simpler, more transparent and faster and will allow for the effective development of national resilience.

Keywords: national resilience, Special Operations Forces, legislation, whole-of-society approach

Introduction

The ever-changing global security environment, terrorism, mass illegal migration, hybrid threats, sub-threshold conflicts, war with conventional forces underscore the need to redefine threats. These threats are now simultaneously multifaceted, affecting the individual, the small community, the state, the region and spilling over into the global space. Moreover, post-modern open societies are more vulnerable to such challenges, which requires addressing the political, military, economic and financial, social, legal and environmental dimensions of security together. The changes already mentioned have also underlined the fact that the role of the military has also changed, because a coordinated political, economic and military response is needed to establish and maintain security.²

¹ Military Representative to NATO and EU Military Committees; PhD student, Ludovika University of Public Service, Doctoral School of Military Science

² 1035/2012. (II. 21.) Korm. határozat Magyarország Nemzeti Biztonsági Stratégiájáról [Government Decree 1035/2012 (II. 21.) on Hungary' National Security Strategy].

Csaba Vida distinguishes between the military, political, diplomatic, economic, financial, industrial, commercial, human, social, environmental, health (epidemiological), legal, public security, national security (intelligence) and demographic dimensions.³ This finding further underlines the need for a whole-of-society approach and underlines the new demands on military capabilities.

At the same time, it is important to note that the capabilities of the armed forces – be it structure, equipment, procedures – are basically designed for the armed defence of the country, so their involvement in strengthening and supporting the non-military segment can only be interpreted within certain limits.

The special operations capability can break through these barriers. Its structure, equipment, training, experience gained in operations in Iraq and Afghanistan, and its regionally extensive network are different from conventional forces. This enables it to effectively facilitate civil–military dialogue, train civilian capabilities and support the development and application of national resilience.

In my study, I argue that Hungary's Special Operations Forces have the capabilities to significantly enhance national resilience, which have already been demonstrated during operations, training sessions and the illegal migration crisis of 2015. At the same time, the proper deployment of these capabilities requires further work to develop the legal framework, to establish a system of cooperation and to allocate resources appropriately.

The concept of resilience

The concept of resilience is not easy to define, as the original term has been taken from other scientific fields and has been given newer and newer meanings. It was in engineering that the concept first became known. It described the ability of materials to retain or regain their original shape despite mechanical stresses. In ecology, it refers to the building up or adaptation of an ecosystem generated by a significant environmental change. In psychology, it refers to coping mechanisms that enable individuals to cope with stress and other negative challenges.⁴ Pál Kádár underlines that the concept has generated some confusion about its meaning due to its transfer from several disciplines. He stated that resilience as a concept has become a fundamental principle of security policy thinking, which is primarily understood as the preparedness and resilience of states and societies against various threats.⁵ In his study, he also underlines that a well-built societal resilience is also a deterrent, as the aggressor must expect to face resistance outside the military defence that will lead to the failure of the aggression.⁶

NATO traces the principle of resilience back to Article 3 of the North Atlantic Treaty – our accession to NATO and the text of the Treaty were promulgated in Act I of 1999 of the Republic of Hungary – which states:

³ VIDA 2013.

⁴ MENKHAUS 2013: 2–3.

⁵ KÁDÁR–KESZELY 2022: 5–6.

⁶ KÁDÁR–KESZELY 2022: 7.

“In order to more effectively achieve the objectives of this Treaty, the Parties, separately and jointly, by means of continuous and effective self-help and mutual aid, will maintain and develop their individual and collective capacity to resist armed attack.”⁷

This principle places military and civilian preparedness under national responsibility. However, in the context of resilience, the NATO context refers to a national and collective capability that can comprehensively address the full spectrum of threats. This includes preparedness, response, resilience and, if necessary, rapid recovery. In a simplified understanding of the Alliance, resilience is understood as the ability of Allies individually, or the Alliance collectively as NATO, to deter threats, to recover from the effects of adversity and to maintain continued operational capability in the face of adversity. At NATO Headquarters, the Resilience Committee, NATO’s lead advisory body, was established in 2022 to lead and coordinate tasks at Alliance level.⁸

In a declaration issued at the Alliance’s Warsaw Summit (8–9 July 2016), NATO expressed its commitment to strengthening resilience and agreed on seven core requirements.⁹

1. maintaining the continued functioning of government
2. maintaining uninterrupted utility services and energy supply
3. managing uncoordinated mass movements of population
4. the continuous provision of basic food and drinking water
5. mass casualty care
6. the maintenance of the national media and electronic communications, and the continuous provision of the IT network
7. ensuring the continued operation of transport and transport infrastructure¹⁰

The European Union has already used the strategic approach as a principle in its Internal Security Strategy in 2010. This has more similarities with the internal content of what is currently known in terms of resilience.¹¹ This was followed in 2012 by conclusions on resilience in the context of the African food crisis, and in 2013 by a European Council Communication on the resilience approach. The first paper on resilience in the European Union was the Strategic Foresight Report 2020. This report identified resilience as the new compass for EU policies. The report defines resilience as:

“The ability not only to withstand and cope with challenges but also to undergo transitions in a sustainable, fair and democratic manner.”¹²

This formulation adopts a multidisciplinary perspective and a broad 360-degree approach. It sees strengthening shock absorption mechanisms and enhancing the capacity to adapt and transform as the basis for a more resilient society. The 2020 Strategic Foresight

⁷ 1999. évi I. törvény a Magyar Köztársaságnak az Észak-atlanti Szerződéshez történő csatlakozásáról és a Szerződés szövegének kihirdetéséről [Act I of 1999 on the Accession of the Republic of Hungary to the North Atlantic Treaty and the Promulgation of the Text of the Treaty].

⁸ NATO 2023.

⁹ NATO 2016; NATO 2024.

¹⁰ NATO 2016.

¹¹ KASSAI 2023.

¹² European Commission 2020: 2.

Report focuses on four interconnected dimensions: social and economic, geopolitical, green, digital.¹³

In the Hungarian context, the National Security Strategy and its annex set out basic tasks for national resilience. Although these tasks are not detailed and are not explicitly defined for the different organisations, the described tasking framework identifies areas where the special operations capability can play a role in building national resilience. Point 124 of the National Security Strategy mentions illegal migration, hybrid threats, terrorism and mass health emergencies, among others, as priority security risks.¹⁴

The government resolution also describes the threats in more detail. In paragraphs 57 to 58, it mentions uncontrolled, mass and illegal migration, with its attendant health, terrorism and destabilising effects on the functioning of states.¹⁵ The migration crisis of 2015 required the deployment of a military response in which the Special Operations Capability carried out significant tasks. The management of irregular migration, hybrid threats and terrorism in a broader sense, and in this regard the support of internal security agencies and police forces could be a clear task for the special operations capability.

The capability to provide mass casualty medical care appears under subsection 174 dealing with disaster risk reduction,¹⁶ which does not fully correspond to NATO's concept of mass casualty care, because it does not narrow the threat down to those arising from a disaster situation alone but rather focuses on the casualties of armed conflict. The care of the injured in armed conflict requires specialised skills, particularly in trauma care, which the special operations capability possesses, as it has demonstrated on several occasions in Afghanistan under the ISAF SOF operation.

The resilience of civilian communication systems, detailed in paragraph 119, which follows in the list of resilience requirements, can also be identified as part of the objectives set out in the strategy document in the context of protecting government and other key information communication systems.¹⁷ A special operations capability equipped with advanced assets can also effectively support national resilience in this segment in the event of civilian service paralysis.

For the special operations capability to provide effective assistance in the cases listed above, it is essential to conduct joint training and preparation exercises.

To summarise the NATO, EU and Hungarian national approach, national resilience is based on a strong state (including a strong economy, social cohesion, governance, modern and effective armed forces, law enforcement, disaster management, healthcare, etc.) and the commitment of citizens. National resilience can therefore only be understood in a society-wide approach.

¹³ European Commission 2020: 8–29.

¹⁴ Government Resolution 1163/2020 (IV. 21.).

¹⁵ Government Resolution 1163/2020 (IV. 21.).

¹⁶ Government Resolution 1163/2020 (IV. 21.).

¹⁷ Government Resolution 1163/2020 (IV. 21.).

A whole-of-society (comprehensive) approach

As challenges and risks do not occur in isolation, but rather in a mutually reinforcing way, it is necessary that the response to them is also implemented through an integrated application of all capabilities. As Tokovicz says: “Complex response to complex crises” – a comprehensive approach is needed.¹⁸ This of course implies the assumption that the development, training and deployment of all areas must be managed in a coherent way. This requires the full cooperation of governmental and non-governmental organisations. However, it should be kept in mind, that different organisations bring different professional cultures and organisational specificities to the joint effort, not to mention society itself, which, with its diversity, can be an obstacle to cooperation.

Keszely highlights the complexity of threats and crises when he states that in a highly complex social environment, the crises and challenges affecting society are also complex in nature.¹⁹ He also refers to the findings of Stern, who distinguished between five complexities in his work *Crisis Decisionmaking: A Cognitive Institutional Approach*, such as political complexity, institutional complexity, historical complexity, information complexity, problem complexity.²⁰ Considering these complexities, the resolution of a crisis requires the involvement of many institutions, organisations and individuals, which can only be addressed on a societal scale, using a comprehensive approach.

In terms of the overall approach, two different models can be distinguished such as integration and coordination. The difference between the two is that integration brings the participating organisations together in a single hierarchical structure, while coordination involves cooperation and direction-setting at the strategic level. When Keszely wrote his study, he saw three different levels of cooperation. These are the inter-organisational level, the intra-organisational level and the intra-national level.²¹ Today, the international trend is integration.

When we turn to Hungary, there are many obstacles to building Hungarian national resilience, especially when we talk about integration. One of the problems stemming from the complexities already mentioned is the cultural differences between the actors involved, which makes cooperation difficult. The communication of subsystems within the system, the different terminology is only one of the obstacles to be mentioned, which is due to cultural differences. Another such barrier is the approach to the problem. The same problem is approached differently by different actors, because the organisational culture, whether it is a disaster management officer, a policeman, a soldier, a paramedic or a public administrator, generates a different focus.

Another obstacle, based on my own experience, is competition between collaborators. For example, during the 2015 migrant crisis, despite the common goal of successful implementation of tasks, unhealthy competition between actors in the solution of subtasks

¹⁸ TOKOVICZ 2013: 11–12.

¹⁹ KESZELY 2013.

²⁰ STERN 2003.

²¹ KESZELY 2013: 49.

occurred several times. It is important to note, however, that these obstacles were always overcome and did not prevent the successful implementation of the tasks.

The key to solving the above-mentioned problems is constant communication and joint training, which gives the opportunity to get to know each other better, to adopt the best practices and to standardise them.

Overall, it can be concluded that building national resilience and a whole-of-government – whole-of-society approach, especially in the light of the experience of the war in Ukraine, requires a level of cooperation – cohesion, if you like – that requires rethinking defence and defence-related systems. This must also include military capability, as its role is changing.

The changing role of the military

The experience of the war in Ukraine has shown that the relative advantage of an aggressor with a significant superiority in conventional military capabilities can be forced into a protracted conflict by well-organised defence and social cohesion. Effective defence in this case requires, on the one hand, a capable defence force which can stop an attacking conventional military. This basically focuses on capabilities that were systematically dismantled in the 2000s, especially by European armies. On the other hand, there is a need for capabilities capable of dealing with hybrid challenges and effectively supporting national resilience.²²

The force development programmes launched across Europe, which Hungary started in 2016 ahead of other European countries, are aimed at restoring traditional military capabilities. On the conventional forces side, this will fundamentally define the tasks for the period ahead. These tasks will focus on training personnel and integrating new equipment. At the same time, special operations capabilities are at a crossroad. This is because in the wars in Afghanistan and Iraq, counterinsurgency or counterterrorism operations were conducted with partner forces, essentially in the framework of military assistance, but the changing challenges of the present era have created a dichotomy with the experience of the war in Ukraine. On the one hand, there has been a renewed focus on special operations support to conventional forces, with an emphasis on traditional special operations capabilities such as special reconnaissance or direct actions. On the other hand, they must continue to be prepared for military assistance and counterterrorism activities in case of hybrid operations.

The above-mentioned changes clearly demonstrate that the role of the military force has changed, especially in the context of the hybrid threat and in the light of national resilience.

Conventional forces will continue to play their part in supporting national resilience, especially in cases where a large general support force or specialised assets are needed. Examples include the 2006 Tisza floods, when 12 military organisations with some 4,500

²² KADÁR–KESZELY 2023: 11.

personnel were involved in the response,²³ or the March 2013 snow emergency, when Hungarian Army tanks and tracked vehicles rescued civilians and first responders on the M1 motorway.²⁴

At the same time, national resilience can only be effectively supported by military units that can react quickly, with the ability to conduct operations in isolation and autonomously over long periods of time. This means that the role of Special Operations Forces and CIMIC, PSYOPS will increase significantly. As part of the defence against hybrid activity, it is to be expected that these special units will be increasingly involved in policing tasks. The basic reason for this is that in the initial phase of a possible hybrid attack, the police will be the first response force²⁵ whose support and reinforcement will be essential. These forces must also be able to play an effective role in preparing society.

Let us look at some examples of the use of special operations capabilities.

In 2023, the Metropolitan Police called in the Special Air Service (SAS) for counterterrorism operations after firearms officers refused to serve in protest because a colleague who shot an unarmed civilian was accused of murder. In response to the request, SAS soldiers were put on standby to be deployed against suspected terrorists if necessary.²⁶

This is not the first time in the history of the SAS that the police have been reinforced. Perhaps their most famous assignment to date was Operation Nimrod on 5 May 1980 when they dealt with a hostage situation at the Iranian Embassy in London. On that occasion they took control of the operation and carried out the hostage rescue at the request of the London Metropolitan Police.²⁷

Operation Temperer which was created in 2015 is another example of military support to police from Great Britain. This is a joint contingency operation to provide military support to the police in extreme national emergency circumstances, such as surge support for a major domestic terrorist attack or threat.²⁸

The ISAF SOF in Afghanistan can also be a good example of how to support the police. Under the ISAF SOF command, soldiers from 26 countries have carried out military assistance missions and built, trained and mentored various special police units attached to the Afghan police.²⁹

The U.S. Special Operations Forces have long been active participants in the Global Health Engagement Initiatives. Under this programme, the U.S. SOF provides health assistance to civilians in areas where health care is severely challenged. Soldiers from the 3rd Special Forces Regiment have provided care to more than 400 civilians in Burkina Faso, and in 2017, soldiers from several countries supported Niger as part of Exercise Flintlock.

In 2011, a veterinary officer provided assistance in Mali, where he worked with a local Tuareg veterinarian to identify and treat surra, a parasitic disease of economic importance

²³ TUNYOGI-FÖLDI 2007.

²⁴ TAMÁSI 2013: 70.

²⁵ CAVES et al. 2021.

²⁶ DODD-MOHDIN 2023.

²⁷ SOF News 2023.

²⁸ Home Office News Team 2024.

²⁹ SMETHURST 2013.

that affects camel herds living in the border region of Algeria, Niger and Mauritania. The Mauritanian Government has supported the veterinarian with a civilian military support element to continue the work against surra. Building on this success, the 10th Special Forces (Airborne) Group sent its Special Forces medical sergeants to a local veterinary training hospital for rotation. In 2013, other Special Forces groups also participated in the exercise, which included a training module on camel handling to assist groups working with Central African countries where camels are used for patrols (e.g. Chad Special Forces – Border Patrol).³⁰

The U.S. Air Force Special Operations Capability actively supported the emergency response to Hurricane Katrina, with fifteen HH-60G Pave Hawk and 347th RQW (Moody AFB, Ga.) and 16th Special Operations Wing (Hurlburt Field, Fla.) crews on alert. In the first 24 hours of operations, 347th RQW rescue crews rescued 211 people, including children and pregnant women.³¹ Although not all of these examples focus specifically on the development of national resilience, they can be used to draw conclusions about how the role of the armed forces is changing and how special operations capability can be used to build national resilience.

However, there is a problem set which can undermine the effective use of the military. This problem set is the slow and bureaucratic political and military decision-making system. We need to make this system more flexible and faster, which requires a rethinking of the legal framework. It is useless to have military capabilities that can be deployed immediately if the decision to use them takes days or weeks.³² In Hungary, the necessary changes are already underway, changing both the legal framework and the defence administration. This was particularly important in the field of defence management because it was necessary to move from the previous monolithic organisation focusing on military tasks to a complex system that, in addition to military and defence tasks, now includes several areas of civilian crisis management.³³ The legislative changes clarify the framework for cooperation between the military, law enforcement, disaster management and civil protection, and civilian (in this sense, all of society) cooperation.

The legal framework governing the use of military capability

The basic task of the Hungarian Defence Forces is defined in Article 45 of the Fundamental Law of Hungary, which states:

“Hungary’s armed forces shall be the Hungarian Defence Forces. The core duties of the Hungarian Defence Forces shall be the military defence of the independence, territorial integrity and borders of Hungary and the performance of collective defence and peacekeeping tasks arising from international treaties, as well as carrying out humanitarian activities in accordance with the rules of international law.”³⁴

³⁰ KINKEAD 2024.

³¹ U.S. Air Force 2005.

³² DRENT et al. 2015.

³³ KESZELY 2019.

³⁴ The Fundamental Law of Hungary 2011.

The wording clearly defines the management of military threats as the core task of the Defence Forces. The detailed rules concerning the Hungarian Defence Forces are contained in Act CXL of 2021. Article 1 paragraph 1 of this law states: “Defence is a national matter.”³⁵ According to paragraph 2 of the same article:

“In maintaining and developing its national defence and allied military capabilities, Hungary relies on its own strength, including the resources of its national economy, the preparedness and determination of the Hungarian Defence Forces (hereinafter referred to as Defence Forces), the cooperation of law enforcement agencies, national security services and other bodies, the patriotic commitment and sacrifice of its citizens in defence of the homeland, and the cooperation and assistance of allied states and their armed forces.”³⁶

This wording is further reinforced in paragraph 3, which reads:

“All natural persons residing in Hungary and legal entities established under the Act shall participate in the preparation for and the performance of national defence tasks within the framework defined by this Act by providing services, and citizens shall also participate by performing personal service.”³⁷

The wording of these two paragraphs already gives us the opportunity to approach the issue of defence of the country, from a whole-of-government, whole-of-society perspective.

The fundamental law also identifies the cases of state of emergencies and their rules. Until the ninth amendment to the Fundamental Law, six different states of emergence were designated: state of exception, state of emergency, pre-emptive defence situation, terror alert, unexpected attack and emergency.

The Ninth Amendment to the Fundamental Law has significantly helped to make the simplification of the legislation of states of emergency more transparent and flexible. As part of this, the amendment has defined three states of emergency: state of war, state of exception and state of emergency. It also introduces the possibility of responding to threats that cannot be achieved by specific armed action as a new element. These striking changes naturally affect the performance of tasks that can be carried out under normal law and have a significant impact on the Hungarian Defence Forces. Unexpected attacks, terror alert and pre-emptive defence situations, which fall outside of NATO's collective defence obligations, have been removed from the scope of the special legal order. They are thus defined as tasks to be performed under the normal legal order. It also removes the possibility of participation in disaster management, so that all tasks that go beyond the basic tasks of the Hungarian Defence Forces as laid down in the Fundamental Law must be regulated by a separate cardinal law. The Ninth Amendment thus allows, on the one hand, for a degree of gradualism to be introduced into the system and, on the other hand, for the defence, law enforcement, national security and the wider public administration to strengthen the cooperation necessary to carry out their tasks.³⁸

The development and coordination of this cooperation is to be facilitated by Act XCIII of 2021 which regulates coordinated defence and security activities (CDS).³⁹ It is intended

³⁵ Act CXL of 2021.

³⁶ Act CXL of 2021: Article 1 para. 2.

³⁷ Act CXL of 2021: Article 1 para. 3.

³⁸ FARKAS–KELEMEN 2023.

³⁹ Act XCIII of 2021 on the Coordination of Defence and Security Activities (CDS).

to be multi-sectoral while at the same time providing for the possibility of intervention at the level of the whole government without imposing the restrictions possible under specific legislation and thus providing a broader mandate than sectoral rules.

The background to the regulation is clearly the experience of the 2015 European terror wave, the crisis caused by mass uncontrolled migration and the subsequent management of the Covid pandemic. These experiences also made it necessary to create the provision according to which the Government may order the Hungarian Defence Forces to participate in the related police tasks in the context of coordinated protection measures. This provision essentially considers the capabilities of the Defence Forces in the performance of non-military tasks in the traditional sense, because the Defence Forces have the capabilities of a high degree of autonomy, a hierarchical organisational structure, a mature command and control system, reliable and sustainable logistical support and personnel that can be mobilised easily and quickly.⁴⁰ As required by the CDS, such tasks must be enshrined in law. Act CXL of 2021 on the Hungarian Defence Forces states the following:

“Article 59 (1) The Defence Forces shall exercise the following functions with the right to use weapons: [...]

(1) contributing to defence and crisis management tasks under the CDS, in particular addressing threats to public order and public security, and coordinated defence activities [...]

(2) The Defence Forces shall perform the following tasks without the right to use weapons: [...]

h) the execution of supporting tasks under the CDS with military expertise and special equipment.”⁴¹

In accordance with the provisions of the CDS, the regulation of the health crisis is governed by Act CLIV of 1997, as amended several times, Chapter XIV of which regulates the health crisis and health emergency response, and paragraph 3 of Article 229 of which defines the tasks of the Hungarian Defence Forces.⁴²

It is important to mention that the renewal of the defence administration in 2014, the 2020 amendment of the Defence Act concerning defence administration, or Government Decree 427/2022 (X. 28.), which formulated the territorial and local rules of defence and security administration and defined specific tasks for territorial defence committees and local defence committees,⁴³ were also important steps in the transformation of the legislative ecosystem. The concept of defence administration is described in detail in Government Resolution 1061/2014 (II. 18.). Based on these:

“Defence administration is a system of tasks and organisations that is part of the public administration, which is an executive activity carried out by the public administration organisation established for the implementation of the defence tasks of the state and designated for this purpose; it includes preparation for states of emergency, as well as all state activities aimed at planning, organising and implementing the tasks of defence, civil

⁴⁰ KÁDÁR 2023.

⁴¹ Act CXL of 2021.

⁴² Act CLIV of 1997.

⁴³ Government Decree 427/2022 (X. 28.).

defence, disaster management, defence economy and public supply in these periods and situations.”⁴⁴

The same government resolution also provided for the development of national defence action plans, which thus form a unified system for the implementation of national defence tasks and military tasks in crisis management.

Even though the restructuring of the regulatory system – a kind of simplification – has made it more effective in building national resilience, there are still obstacles to overcome that are essential to building an effective system.

The change in the defence administration can certainly be a catalyst for the necessary changes supported by the Fundamental Law and Act CXL of 2021. At the same time, the shortcomings of the lower provisions are a problem.

One problem is the lack of regulation of the use of arms. Despite the fact that Act CXL of 2021 contains the basis for this, there is no comprehensive set of rules of engagement which can then be further adapted to the situation. Cooperation with the police may also be hampered by the fact that there is currently no common set of procedures – except perhaps for military police capability – that would make joint service tasks seamless. Since such tasks cannot be integrated into day-to-day training, they must be provided to participating personnel in the context of pre-deployment training. A good example of this was the Temporary Training Task Force in 2015, which prepared soldiers for border service.

A similar problem may arise with the integration of health specialists into the healthcare system, especially during the training and preparation phase, as this raises ethical as well as legal questions.

Overall, it can be concluded that recent legislative changes, even with their shortcomings, provide an adequate basis for the effective use of military capabilities in a coordinated, whole-of-government approach. At the same time, there is a need for a continuous review of the legal framework and a renewal of the lower level of regulation because, as Petruska et al. have noted, the regulation of states of emergency has common features, but there is no one-size-fits-all solution in this respect and therefore no one-size-fits-all solution for all times.⁴⁵

The Hungarian Special Operations capability

In Hungary, the development of a special operations capability began in the early 2000s, when an ad hoc working group at the General Staff Operational Directorate started to prepare the development of the capability. The process accelerated in 2005 when the Special Operations Battalion was born at the base of the 34th Bercsényi László Reconnaissance Battalion.⁴⁶ The amendment of the military organisation’s founding document added the “execution of special operations”⁴⁷ to its scope of activities, which allowed for

⁴⁴ Government Resolution 1061/2014 (II. 18.).

⁴⁵ PETRUSKA et al. 2023.

⁴⁶ SÁNDOR 2024.

⁴⁷ Resolution 22/2005 (HK 7) of the Ministry of Defence.

a change in the mission statement. Subsequently, a further amendment was made to the founding document, detailing the specific tasks that characterise the operation of such an organisation. The new tasks include the three basic tasks such as special reconnaissance, direct actions and military assistance. The founding act also listed additional tasks such as the execution of military tasks in the fight against terrorism, search and rescue and combat search and rescue. A framework task was added to deal with special events requiring the unforeseen use of military force.⁴⁸

The characteristics of special operations justify the way in which the military organisation is set up, the specific structure and equipment, as well as the selection, training and preparation of personnel. The characteristics of operations are set out in the Ált/49 Hungarian Defence Forces Special Operations Doctrine, which includes, inter alia:

- a) "Special operations are focused on complex, politically and militarily high-profile, high-risk tasks (high-value, high-pay off targeting). Special operations are activities characterised by the combined or separate effects of military, diplomatic, economic or psychological effects.
- b) By its very nature, it often requires political, military and national/alliance-level agreement, oversight and support. It requires detailed planning and close cooperation with other commands, services, law enforcement and governmental, state, military and possibly non-governmental organisations of high security importance. [...]
- f) It is often used when the use of conventional forces is not possible, justified or feasible for political or military reasons. [...]
- h) They usually carry out their tasks in isolation from the designated supporting element and, in most cases, from their own troops, requiring covert liaison, adequate means of infiltration and exfiltration, to and return from hostile, prohibited, or politically and militarily sensitive areas."⁴⁹

The special operations team is made up of soldiers specially trained according to the mission statement, who are also deployed in a structure that is unique, and different from the traditional one. Their weapons, equipment and technical means are lightweight and can be deployed quickly, even by air. Their operations are basically planned at the Joint Force level and are carried out by the teams also at this level. Since one of their basic means of deployment is air transport, which requires cooperation with the air force, joint action is in their blood. Cooperation with partner forces, be they police, intelligence, or partner forces in an international environment, local government representatives, is also a capability of the military organisation at the team level, as has been demonstrated in Afghanistan.

The unit itself and its groups can carry out operational tasks in complete isolation, autonomously and on a sustained basis.

Special operations subunits usually have six teams, of which one team is qualified for high altitude parachute jump, two teams for static line parachute jump, two teams for vehicle mobility operations, and one team for combat diving. The ground movement of the

⁴⁸ Resolution 128/1997 of the Ministry of Defence.

⁴⁹ Ált/49 Hungarian Defence Forces Special Operations Doctrine: 1–5.

group is usually executed by three off-road vehicles, but the military organisation also has armoured vehicles.

The special operations team usually consists of 12 people, commanded by a captain, trained in military decision-making. This means that he can solve complex problems and organise, plan and lead the activities of a subunit (400 to 800 people) up to battalion level.

The assistant team leader is a Warrant Officer and has similar professional qualifications (the Basic Special Operations Course 18A and 180A are practically one course) as the Team Leader. The team NCO is basically responsible for the training and day-to-day activities of the team. The intelligence NCO is responsible for the acquisition and dissemination of reconnaissance information, preparing area assessments, etc., is trained in the handling of reconnaissance technical tools (UAV), equipment. These four people form the senior staff of the team.

It becomes clear from the above that the staff element of a Special Operations Team is capable of planning, organising and conducting complex operations, including long-range patrols as well as high-risk detention operations. In addition, it can plan, organise and execute training missions, as well as conduct field reconnaissance and data collection that supports the higher HQ's decision-making.

The eight other members of the group are as follows. Two weapons specialists, who are not only responsible for the team's weaponry, but are also familiar with the handling of the most common infantry weapons in the world. In the event of deployment, they are responsible for selecting and securing the team's deployment site. The two engineer specialists are essentially responsible for the dual role of demolitions (mainly in the execution of tasks involving the use of explosives) and construction, whether it be a firing position, a bunker or a building. Two medical specialists who have the longest training in the team. Their training makes them professional trauma care providers. The two communication specialists are basically responsible for the team's communication, which includes the management of the available technical equipment and the ability to plan and organise the communication architecture, be it voice and/or data.

As described above, the team has a multi-purpose application in building national resilience. Whether it be training civilians in military, defence or emergency response, technical work to support defence or even day-to-day tasks, medical reinforcement with a particular focus on trauma care in areas where civilian medical assistance is not available, or the development and operation of a communications and information system that can temporarily replace civilian service with military capabilities.

Unfortunately, the equipment, technical tactics and procedures of the teams are highly classified and therefore it is not possible to describe the possible use of the teams in full depth in this paper. The team can work as a single unit or split up to cover a larger area with two sections of six.⁵⁰

All in all, the flexible special operations capability, which is essentially based on small subunits, can react quickly and be deployed immediately. Their training and readiness enable them to successfully conduct a wide spectrum of operations, in this case in support

⁵⁰ SoF 2020.

of national resilience, in highly dynamic to changing environments.⁵¹ The technical tools used by teams and special operations operators such as advanced communication systems, data collection, processing, and rapid decision-making capabilities can also support the integrated security of civilian sectors.⁵² Their knowledge of unconventional warfare and their experience in the theatre of war in this regard also make them well suited to support the development and operation of a national resilience capability. The above shows that the Hungarian special operations capability can effectively support the development and operation of a national resilience capability.

Possible tasks for special operations force in support of national resistance

To answer this question, it is worth first identifying the areas where special forces can be effective. Looking at the seven NATO core requirements, four broad areas can be identified: the first is support to law enforcement and national security services, the second is support to training, education and preparation of elements of the national resilience system, the third is support to civilian communication systems and the fourth is support to the healthcare system, particularly in the event of mass casualty incidents.

Law enforcement agencies, national security services

From a law-and-order perspective, public security and the maintenance of public order are not only the protection of the functioning of the state, but also the protection of the state as a system of tasks. This is essentially the responsibility of the police and the national security services, although the capabilities of these organisations can be overstretched in hybrid circumstances. The ability to deal with tasks requiring a larger force in several places at the same time can be a major challenge for law enforcement organisations. In addition, effective use of these organisations has an impact on citizens' perception of security and, through this, on the perception of government and governance.

One good example of this was the illegal migration crisis of 2015, which required the use of military force. The Special Operations Capability, as the Hungarian Defence Forces' Rapid Reaction Interim Contingency Force, was in the operation area within 24 hours of the alert. Thereafter, it basically provided support to the police in areas where there were insufficient police presence, or the necessary reinforcements had not yet arrived. The same unit carried out – in less than 24 hours – the temporary technical closure of the 41 km border section, thus completing the southern border closure.⁵³ For this task, the unit was reinforced with conventional military capabilities deployed in the area. In addition,

⁵¹ DOMINIAK–BASSETTE 2021.

⁵² REZNIKOVA 2022.

⁵³ Mandiner 2015.

the Special Operations Forces personnel on the ground were involved in the “entry” of migrants, screening and information gathering.

Another example is the counterterrorism exercise carried out in Szolnok in 2016. The reason for the exercise was to test the ability of the two organisations to cooperate in a complex situation, as a further step in the already existing teamwork that has been in place between the two organisations for several years. The exercise was set up on the basis of the hybrid threat approach, whereby in the event of a real hybrid attack, terrorist acts are likely to be executed in several locations at the same time or near in the same time, which would “overload” the specialised capabilities of the Counterterrorism Centre, so it is logical that a military organisation with similar training, equipment and professional experience should be involved as a reinforcement.

Support for training, education and preparation of the elements of the national resilience system

One of the core tasks of the Special Operations Forces is military assistance and unconventional warfare. Both tasks involve the training, preparation and execution of an operation by partner forces. During their training, special operations soldiers learn the basic methods of “adult education”, so to speak, which enable them to transfer knowledge appropriately. They can provide not only training, which is essentially practical, but also education, which is still carried out by the personnel of the military organisation today. Training is not only about the transfer of knowledge, as the training carried out by special operations soldiers can also provide psychological and moral support to the personnel carrying out the tasks of national resistance.

Necessary support for civilian communication systems

The Special Operations Unit is currently equipped with the most advanced information technology systems currently available. The system is based on world class radios, which are capable of opened and secured voice and data communications. The devices are, of course, satellite-capable, which, with the necessary accessories, can use civilian satellites. In addition, the teams also have a mobile phone system capable of using combat applications. Several different communication devices are available for the Special Operations Team. Using a team or a split team method, it can provide simultaneous communications in several areas where civilian services may not be available.

Supporting the healthcare system, especially in the event of mass casualty care

The teams’ medical specialists undergo a rigorous medical training before they are deployed. The concrete implementation of their training is laid down in Decree 2/2014 (II. 28.) of the Ministry of Defence, which defines the categories of training level and the

possibilities of intervention of the trained persons. Based on these, the medical specialists of the teams must have a minimum qualification of Operational Medical Specialist. An operational medical specialist means a “soldier without civilian medical qualification who, through specialised medical training in accordance with this Decree, is qualified in Hungary and abroad to recognise various injuries, illnesses, to treat combat casualties, to perform life-saving tasks and to provide general medical care as defined in Annex 3, in the course of military activities in peacekeeping operations and in theatre of operations and for other reasons, in Hungary and abroad”.⁵⁴

The focus of the training is on trauma care, which stems from the basic operational requirements. At the same time, trained personnel can recognise and treat various diseases as necessary. This stems from the requirement for teams to carry out sustained operational tasks in essentially isolated locations where adequate medical care is not available. Their equipment is also assembled in accordance with this requirement. Their capabilities and activities are, without being exhaustive, as follows:

- to perform activities specified in the training requirements independently or in cooperation with others in the course of military duties
- to cooperate with the medical corps and partner organisations, to stabilise and monitor the condition of persons who have suffered acute health damage during direct involvement in military operations, and report on the patient to the person performing the evacuation of the wounded
- adapt the flow and quality of care to the tactical situation
- perform life-saving interventions according to their abilities
- start/carry out primary interventions
- contribute to mass casualty care
- provide instrument-based airway protection in emergencies
- perform wound care according to their level of ability
- act as the first responder unit in a mass casualty incident
- classify the casualties until the arrival of the scene commander
- set up a collection point for the wounded
- provide a peripheral vein
- administer intravenous medication and infusion therapy according to their skills and abilities
- create the conditions for on-site childbirth guidance, prepare the birth attendant for the birth
- if necessary, deliver the baby on the spot
- carry out the first care of a newborn baby
- provide basic veterinary care for working dogs⁵⁵

⁵⁴ Decree 2/2014 (II. 28.) of the Ministry of Defence.

⁵⁵ Decree 2/2014 (II. 28.) of the Ministry of Defence.

As the above list shows, the health specialists in the teams can effectively support the national resistance system and can provide the necessary support if the health response system is “overloaded”. The soldiers have proven their readiness not only in exercises but also in real life.

The risks of using special operations forces in building national resilience

There are risks to be considered when using special operations teams in support of national resilience building. One of these risks is the overloading of the special operations capability. In an armed conflict against a peer, near-peer adversary, special operations teams may have a particularly important role to play in neutralising A2AD⁵⁶ systems, which are essentially focused on special reconnaissance and direct operations.⁵⁷ This requires teams to be highly trained and equipped with the necessary equipment. The development of national resilience and the implementation of and preparations for the above-mentioned mission structure may result in overstressing the limited available teams.

The second risk is that in the absence of a legal framework, during training, preparation or deployment, the implementing soldiers may overstep boundaries that undermine the success of the overall operation. In training and civil emergency tasks this is particularly the case for medical specialists. The execution of an intervention for which there is no legal authority, or the possible occurrence of a complication that can be attributed to the possible failure of the medical specialist without an appropriate legal framework, can undermine the credibility of the capability, the confidence of civil society in the capability and the overall success of the operation. The same problem arises when supporting the police, since without proper rules of engagement, the use of force or the use of firearms becomes questionable. It is important to understand that soldiers and police officers may only have tenths of a second to decide, while their investigation can take months. Without proper regulation, this trend will result in either a lack of courage or hesitation on the part of the officers to make decisions. This can undermine joint action and can pose a problem during the execution of operations.

The third and perhaps the most serious risk is the involvement of special forces in tasks that can be carried out by conventional forces. Unfortunately, I have personally experienced the involvement of special operations teams in tasks that could have been carried out by conventional forces. A good example is the management of the 2015 migration wave. More than once during crisis management tasks, soldiers had to perform simple patrol duties instead of focusing on night deep interdiction tasks where they could have put pressure on the smuggling networks.

⁵⁶ Anti-Access Area Denial.

⁵⁷ BROWN 2022.

Summary

In conclusion, the conditions for building national resilience are basically in place. The necessary legislative reform has started, and the legislative changes made so far provide an appropriate framework for building resilience.

The military capabilities are basically available, but the change in the use of military force, which occurs at the same time as the development of the capabilities of the armed forces, has a fundamental impact on the integration of the capabilities of the armed forces into the development of national resilience.

Conventional forces can still provide the “mass” for support tasks, but any such activity will hinder the possibilities for training and preparation, which may have a negative impact on the primary task of conventional forces to defend the country with combat operations.

The dichotomy in the tasks of the Special Operations Forces can also be an obstacle to the involvement of the Special Operations Forces. At the same time, it is important to underline that the tasks of the Special Operations Forces in support of the national contingency capability are also reflected at the level of the basic mission, so that their execution does not overburden the capability. The structure, training and experience of the available capability clearly support the conclusion that the Special Operations Forces are capable of effectively supporting the development, preparation and operation of national resilience.

To build national resilience, the command-and-control system of the special operations capability and the structure of the SOF organisation itself need to be rethought. The current system is a temporary solution to existing professional and workforce shortfalls, but it is a permanent impediment to the optimal management of the special operations forces. Further progress is needed to reform the education, training and exercise system. The system needs to be much better coordinated with the police counterterrorism centre, the local police, the first responders, and finally with the representatives of defence administration which is the basis for joint action.

The Special Operations Capability should open to both conventional forces and civil society. In this regard, the special infantry training should be relaunched, which specifically targeted the reserve system – through civil society – and which was unspokenly the basis for a reserve Special Operations Capability.

All in all, the changes that have been made are very supportive of the involvement of special forces in building national resilience, but there is still much work to be done to build a successful and effective capability. Unfortunately, the current security situation is not in our favour, so we must make every effort to accelerate progress.

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Changes in Educational Technology and Teaching Methods Due to Technological Developments and 3D Printing

Zoltán KOVÁCS,¹  István EMBER,²  Róbert VÉG,³ 
Norbert DARUKA,⁴  Kálmán DÉNES⁵ 

Teaching methods are constantly evolving, and the amount of teaching material is increasing year by year. The more effective acquisition of the expanding range of knowledge and the easier understanding can be greatly facilitated by the illustrative materials and educational aids, produced by 3D printing. In our article, we briefly describe the main characteristics of basic teaching methods and the advantages of using novel 3D technology in education, especially in military officer training.

Keywords: 3D printing, training aid, illustrative object, military higher education, officer training

Introduction

Effective education requires rethinking who, whom, what and how to teach. The answer to the question of “who” and “whom” is easier and given, because of course the best, most up-to-date teacher should teach students who have entered the education system after a successful admission procedure and who feel a sufficient commitment to their chosen subject. Commitment to education and teaching is an essential but not a sufficient condition for teaching. Teaching is the main factor affecting the effectiveness of education, i.e. the education system is only as good as the teachers who make it up.⁶

¹ Associate Professor, Department of Combat Support, e-mail: kovacs.zoltan@uni-nke.hu

² Assistant Professor, Department of Combat Support, e-mail: ember.istvan@uni-nke.hu

³ Associate Professor, Department of Military Technology, e-mail: vegh.robert@uni-nke.hu

⁴ Explosives industrial engineer, e-mail: daruka.norbi@gmail.com

⁵ Civil engineer, e-mail: denes.kalman.1975@gmail.com

⁶ NAGY-CZIROK 2016: 45–47.

The answer to the question “what” is also determined by the need to teach marketable knowledge that can be applied to the job. Education plans determine the curriculum according to what is wanted and what is available. How to teach is essentially determined by the organisation of the teaching process, the methods and the technical means of teaching.

Education is a regulated process, not only in terms of content but also in terms of form, and can take the form of classroom-based activities (theory, practical, laboratory), professional practices (e.g. work experience, industrial placements), workshops and scientific student groups, and field trips (factory visits, museum visits).

The key to effective teaching is to choose teaching methods that are appropriate to the teaching objective and to apply them in a variety of ways that match the students’ level of knowledge and the specific nature of the subject. The types of work that can be used to teach students include frontal class work, group work and individual work.

In case of frontal class work, the teacher has the greatest role to play in explaining and delivering the subject matter through individual presentation and the use of teaching techniques. In order to achieve common educational objectives, the learning activities of the students are carried out at the same time, usually at the same pace. This is the quickest and most effective way of delivering the material, which can be used in large class sizes, but it has the disadvantage that the teacher is not informed about the different pace and depth of learning of each pupil during the face-to-face teaching, and is therefore unable to adapt the teaching to the pupils’ performance.⁷

In group work, students work in small groups (3–6 students) on a given task in which they have a relationship of dependency, responsibility and control. Groups can be formed by the teacher or by the pupils themselves. In group work, they learn to listen and listen to each other, to represent their own interests (knowledge), to learn about learning procedures, to practice time management and division of labour.⁸

In case of individual work, the student learns the assigned course material independently. Individual work develops the ability to focus, to collect data efficiently and to work independently. The teacher can differentiate and get to know the individual characteristics of the students better. A disadvantage of this form of work is that it can lead to a “pigeonholing” of learners on the basis of knowledge, which can be difficult for them to penetrate later on.⁹

It is the level and form of education that determines how much weight is given to particular forms of work. In higher education, the role of face-to-face class work in the transfer of knowledge is increasingly being reduced and more personalised forms of work, such as small group teaching or individual tutor-led learning, are being introduced.

⁷ VARGÁNÉ KISS 2009.

⁸ GAÁL–JÁSZI 2024.

⁹ RADNÓTI 2006.

Organisational forms and framework of education

The basic form of organised school education is the classroom, which is traditionally categorised according to the dominant didactic task of the class. When breaking down the curriculum, the type of successive lessons cannot be clearly defined. The intellectual and physical composition and attitudes of a given group of pupils require different formal and methodological teaching of the same subject, and therefore different types of lessons. Several views have emerged on the categorisation of lessons, e.g. that the most important task is not to set a didactic objective, but rather to choose the appropriate tools according to the circumstances. However, the most common way of describing the types of lessons is still the traditional didactic approach, which is the most concise, i.e. lessons can be a new knowledge lesson, a practice lesson, a revision lesson, a systematic lesson, a summary lesson and a control and evaluation lesson.¹⁰

A new knowledge class is the type of class that is used in the majority of education, the main purpose of which is to provide knowledge, to teach new concepts, laws, rules and contexts, and which can be an introductory class, a “homogeneous” class, or a “mixed” class. It should be borne in mind that new material should be based on existing knowledge. In the introductory part of the lesson, references should be made to the knowledge previously acquired, to shed light on the subject matter of the next lesson and to arouse the interest of the students in the new knowledge to be acquired. During the presentation of the new material, constant references should be made, both to reinforce the positive experience of their own knowledge and to draw attention to any gaps in their knowledge that may make it difficult to process the material. It is a good idea to have an introduction lesson at the start of a new topic, to establish a link with previously covered chapters and knowledge, and to create motivation for the next topic. The methods and teaching aids used in the introduction can be varied and can also be used to assess students’ prior knowledge. In a homogeneous lesson (the whole time), the new knowledge is covered and there is no repetition, practice or monitoring. The teacher uses an analytical, analysing method to synthesise the new knowledge, but may have difficulty in maintaining the attention of the pupils throughout the lesson. Mixed type lessons are the most common type of lesson where new knowledge is transmitted, processed and checked. It may involve practice, repetition and organisation alongside the transfer of new knowledge.¹¹

Ideally, the acquisition and application of knowledge are not sharply separated, but form a single unit. Practical lessons are important for the development of skills and competences, providing opportunities for independent tasks, group work and cooperation. It can also be a practical or experiential lesson where students can develop their sensory and manual skills. During the practical lesson, students can learn about and physically touch the structural elements, and as their theoretical knowledge increases, it becomes more of an individual or group task to be carried out.

A summary lesson should be included in the curriculum at the end of a unit of study, where the aim is to summarise, organise, unify or put the material in a new light. It

¹⁰ KRISKA–KARKUS 2022.

¹¹ CZIGLÉNÉ FARKAS 2008.

is advisable to repeat and organise a section of material from several angles, because presenting it from multiple perspectives helps students absorb the curriculum more quickly and deeply. The lesson should provide an opportunity to develop a new perspective, to highlight the essential links and to develop the relationship between theory and practice. A summary lesson can be effective if the concepts related to the summarised material are clearly and unambiguously captured. Self-checking and self-assessment play an important role in the lesson. A summary lesson is good if it is possible to point out gaps to the pupils so that they feel they have the opportunity to make up for them before the examination.¹²

The revision lesson is usually followed by the control lesson, which in many cases involves the writing of a final examination paper. In higher education, written forms of control have become almost the only form of control, because they are more suited to the requirements and quality of higher education and because oral control would take too much time.

Traditional and modern teaching methods

An important element of effective learning in education is the teaching method used, which should be adapted to the level of knowledge of the students and the specific nature of the subject. The use of a combination of teaching methods is usually advisable, as it promotes active learning, the development of critical thinking and the ability to work in teams. Teaching methods can be divided into traditional (lecture, explanation, narration, discussion, student presentation, demonstration, project method, work-based method, field trip) and modern teaching methods (M-learning, gamification, blended learning, E-learning,¹³ etc.).

The appropriate use of different teaching methods plays an important role in the training of students, not only to increase their knowledge but also to develop the key competences they will need in the labour market to meet the challenges of the 21st century. Education should include critical thinking, problem solving, creativity, communication, teamwork and independent learning.

Lectures are one of the most common and most frequently used teaching methods, where the instructor explains a topic in a logical and detailed way in an oral presentation. It is possible to use explanation and narration simultaneously. The main parts of the lecture are introduction, explanation and summary. The purpose of the explanation is to facilitate the understanding of concepts, rules and contexts and is shorter in length than the lecture. Explanations can be interpretative (to define concepts and describe characteristics), descriptive (to describe the characteristics and operation of a process), or explanatory (to explain the causes, consequences and context of a phenomenon).

Narration is a way of presenting a topic to the students in sufficient detail and in an experiential way, while the emphasis is not on exploring cause and effect, but on stimulating the students' imagination and emotions. Through narration, students can imagine events

¹² NYÉKI 2016.

¹³ KORPICS et al. 2023: 37–39.

and processes related to the subject matter, thus becoming active participants in the learning process. Discussion is a teaching method where the processing of the material is based on discussion through questions posed by the teacher. Discussion encourages active participation and makes students think and formulate their own opinions on the material.¹⁴

Student presentations help students to participate more actively in their learning, increase their confidence and develop their research and presentation skills. It can be on any topic in which students have the opportunity to carry out independent research. Illustration can be used to study tangible things related to the topic. The student can get hands-on experience of the objects related to the subject matter and thus better understand how they work, which is beneficial for the acquisition of knowledge. Visualisation helps to develop the pictorial thinking necessary to understand concepts and to master certain activities. The project method relies on the active participation of students and the collaboration between teachers and students, which transforms the learning process into a series of projects focusing on different learning materials. The project method not only promotes the acquisition of knowledge but also develops students' problem-solving skills and creativity.¹⁵ It promotes students' active participation, autonomy and creativity, while supporting the learning process.¹⁶

In the employer approach, students acquire the necessary knowledge and skills through manipulative activities. During the activity, they observe the properties of objects and parts in relation to each other, thereby acquiring new knowledge using their previous knowledge.¹⁷ During the field trip, students leave the classroom and learn about the topics covered in the curriculum in a real-life location. The advantage of this teaching method is that students can experience what they have learned in real life, increase their motivation, gain practical experience and, last but not least, it can be an excellent way of building community.

Gamification

Gamification is a method of applying game elements outside the game, e.g. in education, to make learning more interesting and to influence students' behaviour in a positive way. Gamification is based on the human desire for recognition, so the gamification method can be a powerful motivating factor. When participants are rewarded, it encourages them to make an effort to do activities that they initially thought were boring.¹⁸ In the gamification method, participants collect various points and prizes, which play an important role in feedback and performance evaluation processes. The advantage of a points system is that the emphasis is on accumulating points and achieving small successes rather than on merit-based assessment (of course, grading based on marks is still possible). Gamification elements and small competitions can be incorporated into the curriculum,

¹⁴ BENCZÉNYÉ FEKETE – SCHLICHTER-TAKÁCS 2022: 92.

¹⁵ BENCZÉNYÉ FEKETE – SCHLICHTER-TAKÁCS 2022: 152.

¹⁶ LADA 2009.

¹⁷ KORPICS et al. 2023: 39.

¹⁸ FROMANN–DAMSA 2016: 78.

where students are awarded points for reaching a certain level. Great emphasis should be placed on careful and precise preparation in the design of playful units. The nature of the game may also involve competitive elements where the results achieved can be made public. In gamification, the points and badges achieved and earned may not be sufficiently motivating for students, it can only be successful if it is sufficiently exciting, non-monotonous and challenging.

Blended learning

Blended learning combines classroom-based learning with distance learning, allowing students to learn at their own pace, while still having the opportunity to meet the teacher face-to-face. Blended learning provides the ideal learning mode for the student without space and time constraints. “An educational technology that makes the learning material accessible through a variety of learning environment elements (methods and tools), traditional and virtual classroom learning formats, face-to-face and distance communication, print and electronic learning materials, high quality info-communication tools, cooperative, varied methods, individualised learning, ensuring the monitoring and evaluation of the learners’ progress.”¹⁹

The benefits of blended learning can be seen in the more time for teachers and students to work creatively and cooperatively in the classroom, the emphasis in lessons on deeper understanding, practical application and group work, and the ability for students to take advantage of online learning while maintaining the personal contact with peers and teachers that traditional education provides. Blended learning expands communication opportunities, allowing students to interact with instructors and peers through mixed channels (chat, video, online forum), which fosters critical thinking, problem solving and collaboration. Students will become more technologically literate and improve their digital literacy (which can be an advantage in further education and job search), increase their self-motivation, self-responsibility and develop discipline, as they are largely self-reliant in their learning.²⁰

In blended learning, it is important to keep the curriculum up-to-date, incorporating the latest information to ensure that students are up-to-date with the knowledge they need in the 21st century labour market. The disadvantage of blended learning is that not all students are ideally suited to using online modules, some find oral explanations more understandable and easier to learn. The time constraints of independent study are not always well managed by all students, and lack of motivation can also be a problem. A disadvantage is that it takes a lot of time for the teacher to prepare and develop useful learning materials.

¹⁹ FORGÓ 2004: 12.

²⁰ BÁNKESZI-SZEPESI 2018.

E-learning

The spread of infocommunication technologies provides a good opportunity for the expansion of electronic forms of distance learning. E-learning uses electronic devices (computer, smartphone) and media for learning. Modern e-learning technologies (online courses, virtual classrooms, video lessons, podcasts) allow students to acquire new knowledge in a user-friendly way, according to their individual learning path, regardless of the number of participants or their geographical location. E-learning reduces the cost of education and allows for large-scale learning, as it is not classroom-based. This mode of learning is appropriate for social sciences and data-based learning, but it is not as effective for learning complex subjects that require complex thinking.²¹

E-learning is delivered through different platforms, such as Moodle, which is widely used, easy to use, capable of storing and editing course materials, tracking student activity, assessing student work and issuing assignments. Moodle also provides the possibility of accountability, contact and messaging. The advantages of e-learning are that it is flexible, can be individually scheduled, saves time because there is no travel time, learning can take place anywhere and at any time, modern learning materials are interactive and experiential, and is cheaper than traditional forms of learning. The disadvantages are that good digital learning materials are time-consuming and require specific expertise to produce, there is no real interaction between the teacher and the student, students are less motivated because they spend less time learning due to too much freedom and e-learning materials do not always fit the individual learning needs of students.²²

M-learning (mobile learning)

It involves learning and teaching processes using mobile technology (mobile phones, e-book readers, laptops, portable media players), thus mobilising not only the learning but also the learner. Mobile learning means using handheld IT devices while learning is mostly fast, mostly at leisure, allowing learners to move at their own learning pace, at their own convenience, which can increase the effectiveness of learning. It has the advantage of enabling students to access learning materials from anywhere and at any time, providing the opportunity for interactive and personalised learning, and increasing motivation to learn. Mobile learning is more than just the use of technological devices, it also represents a new way of teaching. It allows students to communicate easily and quickly with each other and to work on group tasks. Mobile technology can automate repetitive tasks, allowing students to focus their cognitive energy on the more important elements of the learning process, access the latest information and content, and stay up-to-date in their field.²³

²¹ ADY–TERPECZ 2018: 124.

²² MRÁZIK 2021.

²³ KÓRÖSI et al. 2015; BÓNUS–KOROM 2022.

Printed and non-printed teaching materials

The media to be used in education will determine what best suits the educational purpose, content, target group and conditions, whether the medium is provided for the students and whether the students have the learning habits to use the medium. In recent decades, the most commonly used educational tool has been the printed course material. In education, electronic tools and printed learning materials co-exist well and complement each other. Printed learning materials have many advantages, i.e. they are easy to handle and transport, relatively cheap to produce, small in size, can be read twice or three times faster than listening to the same text, encourage the learner to take notes, highlight, underline, and have a “bookish/papery smell”, which is an important consideration for many people. Of course, the printed courseware also has disadvantages, e.g. it is linear and difficult to present knowledge that requires a global understanding, it is less interactive, it has limited remote control, i.e. the self-tests included in the printed courseware can only contain closed questions, while on the computer you can also give open questions. Some of the learning and teaching functions can also be implemented with non-printed learning materials, such as slides, audio cassettes, audio CDs, films, video cassettes, computer-based tutorials, multimedia-based tutorials, digital whiteboards.

Slide films, audio cassettes, video cassettes have been out of use for a number of years, because it is useless to have this form of teaching material if you do not have the equipment to play it. It is also true that CDs and DVDs are hardly usable, because over time these media have become obsolete, and many new computers nowadays do not even have a drive. Multimedia-based teaching materials are good because they take into account the learning needs of students, but they are very time-consuming to produce and therefore relatively few are available. The objective of computer-based instruction is to adapt to the learning needs of students, but also to give them sufficient autonomy. With new digital tools, the focus should not be on the impact of the new tool on education, but on how education can make better use of the new technologies. New innovative technologies complement traditional teaching methods and provide a new pedagogical approach to the educational process.

With a digital whiteboard (interactive whiteboard), a projector and a computer installed in a stable way, we get a teaching system that is in itself just a technical background on which to project and write. This system can only be exploited if the appropriate teaching material accompanies the technical background. The interactive system helps to motivate the student, maintaining interest and increasing the effectiveness of classroom teaching. The use of interactive whiteboards allows students to participate visually and actively in learning at the same time, and is an effective tool for presenting the material and maintaining attention during lessons. You can write or draw in the projected diagrams, pictures and tables to make the teaching even more visual. At any time during the presentation, you can save or even print out the information on the whiteboard. The order in which the material is presented during the lesson is not fixed and does not have to be presented in a linear way, making it easier to adapt to the groups of students and to move at the pace and in the way that best suits them. Multimedia tutorials can be multi-purpose, they can be given to the students, but they can also be used by the teacher for classroom

work and even include self-tests. The only limits to the production of a courseware are time and programming skills, but with the right routine, it takes little more time to produce a multimedia courseware than a well-edited presentation.

Changes in teaching techniques due to 3D printing

The development of educational technology is closely linked to technological progress. The advent of digital technology, the internet, virtual reality and new media, as well as 3D printing, have changed teaching methods and teaching tools.

3D printing provides students with an interactive way to learn about the subject matter, concepts and theories (Figure 1).



Figure 1: Using 3D printed illustrative objects in the classroom

Source: photo taken by the authors

Turning them into tangible objects not only enhances the learning experience, but also helps students to understand complex concepts in more depth. Students can make their own models in or out of class, so they not only learn in theory but also apply their knowledge in practice (Figure 2). The integration of 3D printing into education also allows for project-based learning, where students can find solutions to real problems.

This not only develops their creativity, but also their critical thinking and teamwork. Students are able to implement their own ideas, which can encourage them to research and innovate.

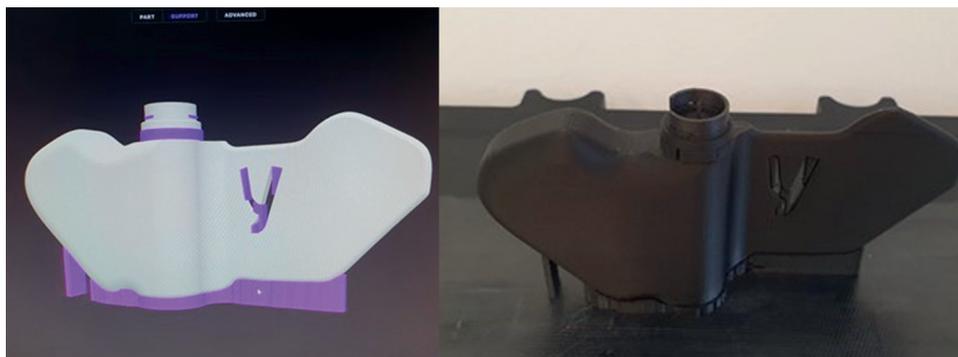


Figure 2: Computer drawing of a landmine (left) and the 3D-printed result (right)
 Source: photos taken by the authors

The emergence of 3D printing in education could change the current practice of frontal classroom work and the spread of learning models based on active participation and student autonomy, such as flipped classrooms, where students learn new skills at home, usually through videos or online materials. In the classroom, students actively apply this knowledge, working on practical tasks and learning from each other under the guidance of teachers. This approach has many advantages, giving students the opportunity to move at their own pace, to revisit the material and to master it better.

On the other hand, the time spent in the classroom allows for deeper interaction with the teacher and fellow students, which helps to develop problem-solving skills and collaborative work. The introduction of a flipped classroom can also present challenges, for example in terms of students' attitudes towards independent work and the availability of IT tools. If implemented well, that highly effective teaching method contributes to active students' participation and deeper understanding of knowledge.

3D printing can help students not only during lessons, but also during home learning, where they can create different 3D models for the classroom and present them later. This method emphasises the importance of research and presentation, which helps students to go deeper into the topic of their interest. While 3D printing and technological advances offer great potential for education, they also present a number of challenges, one of which is accessibility. Not all schools have the tools and resources to integrate 3D printing and other advanced technologies. Another challenge is that teachers need significant training to be able to use these new technologies effectively. The training of teachers is key to ensuring that 3D printing and other technological tools are truly useful to students.

The Ludovika University of Public Service is a unique knowledge centre that offers modern education, competitive knowledge and a specific profession. The training courses offered at the university faculties enable talented young people who are committed to public service to find the career that best suits them. The main task of the Faculty of Military Science and Officer Training is to train military officers for the military organisations of the Hungarian Defence Forces, and also deals with other undergraduate and master's degree programmes, as well as course and advanced training. The Faculty has two doctoral schools for the implementation of scientific research, the Doctoral School

of Military Sciences and the Doctoral School of Military Engineering. In addition to theoretical education, great emphasis is placed on practical education during the training of future military officers, and accordingly, training takes place in classrooms, simulation centres, training areas and at military units.

The use of additive manufacturing and objects produced by this process in education/training has already begun in several areas of military training. Various illustrative tools made with 3D printing bring the textual and graphic information found in textbooks to a “tangible proximity” for officer candidates (students), which helps them understand it more easily and develops their logical thinking and creativity.

Our “digital warehouse” also makes it easier to provide the necessary logistical background for the sessions. There is no need to store, move, periodically count, or transport various materials and tools to and from the practice area in an actual, real warehouse. Instead, according to educational needs, at the right time, based on the blueprints stored in the “warehouse” (design programme), the illustrative/practice objects to be used need to be printed in the required number, size and material (Figure 3).



Figure 3: Printing a 3D object before class

Source: photo taken by the authors

Overall, it can be stated that we can expect the appearance and spread of additive manufacturing technology in all areas of life in the future – including education and training. Various illustrative and practice tools made of plastic or metal using 3D printing make it easier to master complex knowledge and practical skills, thus making military training more effective.

Summary

3D printing has become an important part of everyday life today, as a wide range of users have access to an affordable printer that best suits their needs, which also has many advantages over traditional manufacturing processes.

Even more complicated and complex structures can be manufactured quickly, efficiently and at a reasonable price, in material quality that meets the requirements.

In order to meet the objectives of the military development strategy regarding personnel, we recommend that 3D printing technology education be included in the training system, both in the framework of BSc- and MSc-level training, as well as in specialised courses.

In our opinion, the development of 3D printing capabilities and the creation of closely related educational conditions can contribute to the development of a defence industry that meets the requirements of the time, as well as a modern Hungarian Defence Forces with a high degree of responsiveness.

Project No. 2022-2.1.1-NL-2022-00012 has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the National Laboratory of Cooperative Technologies funding scheme.

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Flood Protection Phenomena in the Körös Region

Attila TÍMÁR¹ 

Since the regulation of the Körös Rivers, and following the construction of the flood protection systems and their development, several phenomena have developed on the embankments as a consequence of the receding flood waves. The following article presents the phenomena developed on the flood protection lines and flood control structures of the Körös Rivers. This information was collected, structured and categorised to better assess the flood protection lines. With the collected data, as well as with data from other sources (such as geomechanics, modelling) recommendations can be made on where and what kind of investment should be made in order to increase flood protection safety.

Keywords: *flood, flood protection, embankments, phenomena, seepage*

Introduction

The Körös region (Romanian: Crişana) is a geographical location in Romania and Hungary, whose water network consists of the Fehér-Körös, Fekete-Körös, Kettős-Körös, Sebes-Körös, Hármas-Körös, Berettyó and Hortobágy-Berettyó watercourses, the geographical location of which is shown in Figure 1.² (Hereinafter, the Hungarian river names are used in this article for a better understanding of the location.)

The Körös region flood protection system and the safe drainage of flood waves are provided by embankments made of compacted soil, the current form of which was achieved by increasing their cross-section (height and width). The permanent retreat of flood waters at high peak levels greatly weakens the protective capacity of flood protection facilities. This generates flood phenomena that can occur on the embankment and its subsoil.

¹ Head of Department, Körös Region Water Management Directorate, Flood Protection and River Management Department, e-mail: timar.attila@kovizig.hu

² SZLÁVIK et al. 1994.

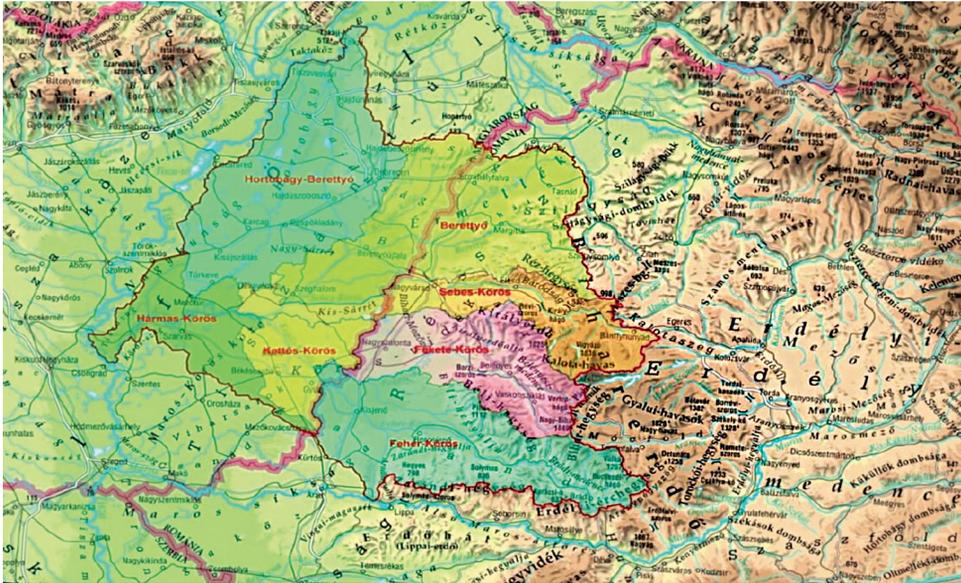


Figure 1: The Körös River Basin and its landscapes
Source: Alföld-Planum Kultúrmérnöki Kft. 2014

Seepages and water flows

For the majority of the levee failures – that are not caused by overtopping – the main reason of the flooding disaster is the water flow that takes place in the soil. Consequently, the damage of the flood protection levee is usually, in absence of overtopping, the consequence of seepage.

In addition to the embankment body, the flood protection levee also includes the part of the subsoil that interacts with the embankment.

To best assess the status of a flood protection line (whether it is safe or not), it is vital to understand the seepages occurring in the surrounding of the protection line (both embankment and subsoil) as precisely as possible.³

Seepages in embankments

The flood protection embankments of the Körös Rivers were built – without exception – from both ditch material and the materials of bound top soils indiscriminately. In the 1970s, the levee reinforcement was done with the same process. This construction procedure entails

³ VÖLGYESI 2004: 61.

that the inside of the embankments is almost without exception of heterogeneous nature. According to measurements made during flooding, considering seepage, the heterogeneity of embankments may occur in three forms: Seepage in heterogeneous embankments (Figure 2); Seepage in the subsoil (Figure 3); Complex seepages in heterogeneous embankments and subsoil (Figure 4).⁴

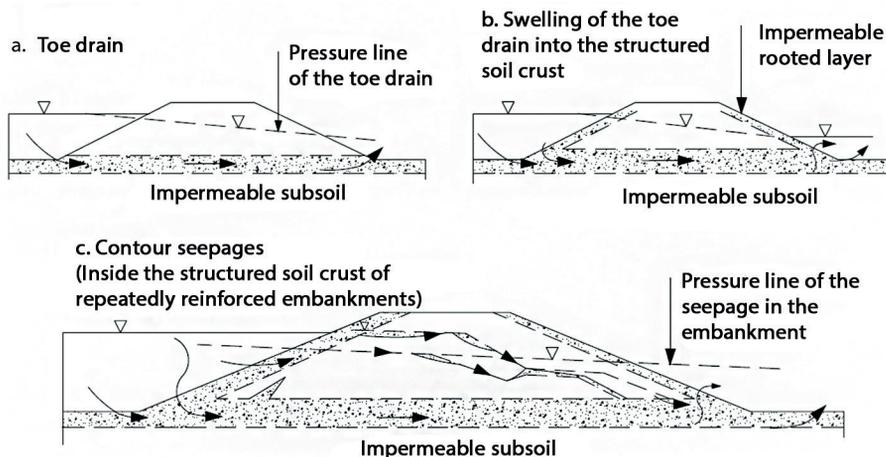


Figure 2: Seepage in heterogeneous embankments

Source: GALLI 1976

Seepage in the subsoil

Regarding seepages, the subsoil in the flood protection lines may always be divided into multiple groups. Firstly, the subsoil can be single-layered, which is either a homogeneous aquiclude or aquifer. Alternatively, according to the general rules of sedimentary sequences, it can also be some sort of a simple-bound layer or a two-, three-layered subsoil covered with bound and fine sand.

From the perspective of seepages, a multi-layered subsoil is also considered a naturally impermeable subsoil given that its bound top soil is so thick that the hydraulic soil failure on the protected side as well as the seepages under the embankments regarding the underseepage are negligible. Seepages may occur both in embankments and in the subsoil.⁵

⁴ GALLI 1976: 49.

⁵ GALLI 1976: 52.

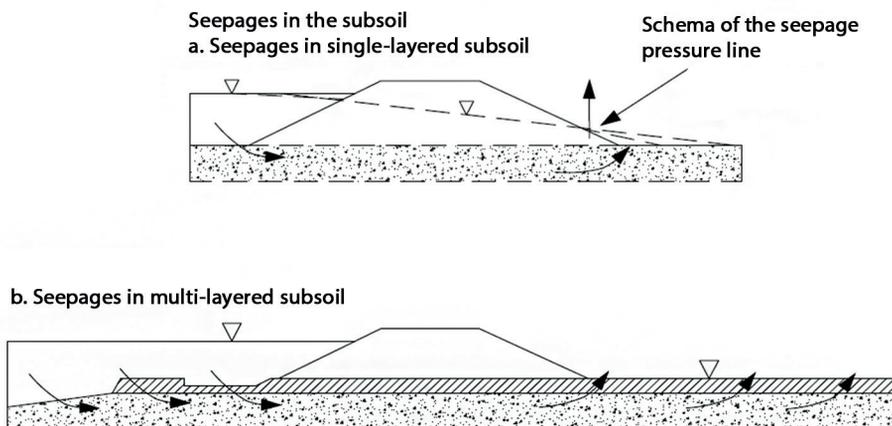


Figure 3: Seepage in the subsoil
Source: GALLI 1976

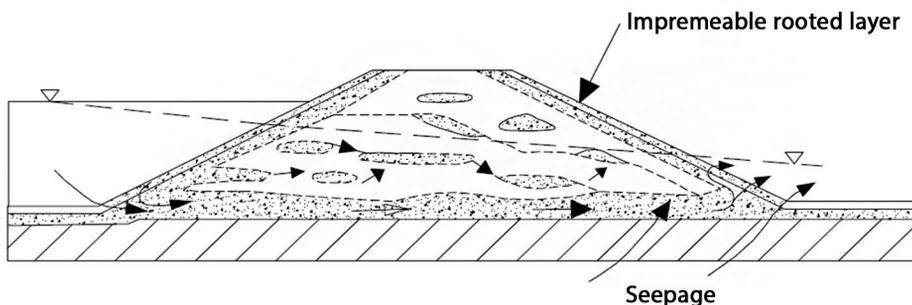


Figure 4: Complex seepages in heterogeneous embankments and subsoil
Source: GALLI 1976

Development of flood phenomena

The water load in different zones of the flood protection dikes leads up to seepages, the intensity of which is often different and also changes over time.

The intensity of the flood phenomenon itself is also changing, nevertheless when examining the risk of a dike break due to seepages, only the flood level is taken into consideration (standard flood level, height of the embankment, or level that can be protected by embankment elevation during flood). However, understanding the duration of the flood or the velocity of the rising and falling phases is also important.⁶

⁶ VÖLGYESI 2004: 64.

Experiences show that the failures caused by seepage has four main characteristics, occurring in four critical locations:

- subsoil stability in terms of topsoil breach
- subsoil stability in terms of sand boil formation
- subsoil stability in the aquifer
- slope stability on the protected side

Embankment and subsoil seepages – apart from the possible damages caused by underseepage – are not necessarily dangerous events. Even if the slope shows separate stains or leakage, or soaking on a continuous surface or even if there is surface wetting and seepage in the safety zone, the stability of the protection line is only compromised if these phenomena cause certain geomechanical processes in the embankment or subsoil that lead to the breach of the flood protection line. The stability of the protection lines and the need for flood protection interventions and possibly the subsequent strengthening of the protection lines must therefore not be based on the occurrence of the seepage, but rather on the expected consequences of the seepage.

Flood protection sections

The flood protection settlements and areas in the Körös region are protected and exempted from floods by flood protection sections, including flood protection embankments (Figure 5).

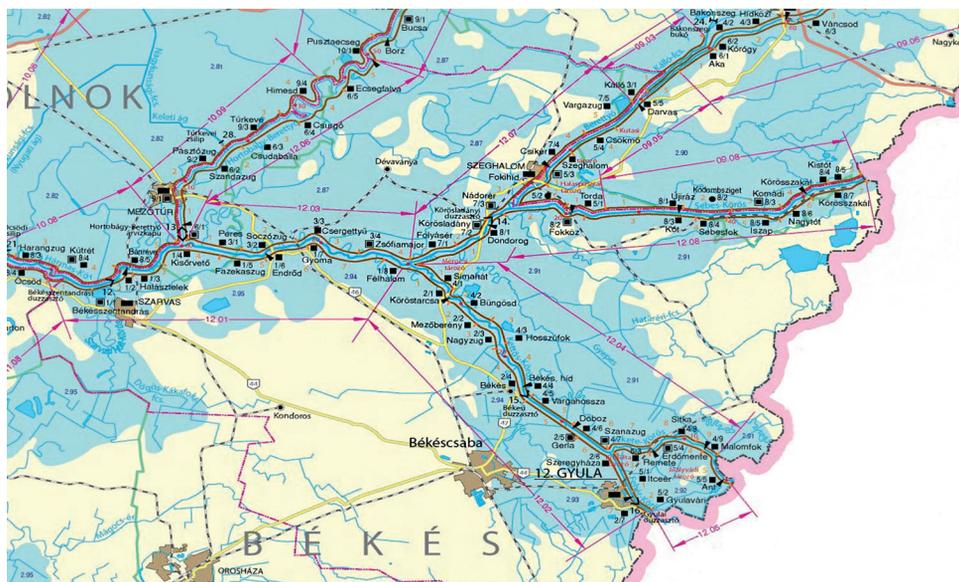


Figure 5: Flood protection system of the Körös Region Water Management Directorate
Source: General Directorate of Water Management 2014

The flood protection sections and lengths of protection lines in the Körös Region Water Management Directorate (hereinafter KÖVIZIG) area are summarised and presented in Table 1.

Table 1: Flood protection sections and protection lines in the KÖVIZIG area

Protection section number	Dike location (River)	Dike length (m)	Embankment length (m)
12.01	Hármas-Körös left bank	49,117	49,117
12.02	Kettős-Körös left bank, Fehér-Körös left bank	9,286–35,040	44,326
12.03	Hármas-Körös right bank	28,413	28,413
12.04	Kettős-Körös right bank, Fekete-Körös right bank	16,059–36,193	52,252
12.05	Fehér-Körös right bank, Fekete-Körös left bank	9,475–20,490	29,965
12.06	Hortobágy-Berettyó left bank	43,210	43,210
12.07	Sebes-Körös right bank, Berettyó right bank	14,013–21,313	35,326
12.08	Sebes-Körös left bank	57,966	57,966

Source: 12.01.–12.8. KÖVIZIG árvízvédelmi szakaszok. Műszaki leírás [KÖVIZIG Flood Protection Sections. Technical Description] Körös Region Water Management Directorate

Flood protection phenomena

In the past 57 years, there have been 20 flood waves in the river basin of the Körös Region Water Management Directorate (on 8 flood protection lines) when a flood phenomenon occurred.

According to the registry data, a total of 3,798 phenomena were documented over nearly six decades, which is equivalent to 1,283,806 metres on all the 8 flood protection lines.⁷

Table 2 shows the data per protection lines:

⁷ Árvízvédelmi tervek. Észlelt árvízi jelenségek JEL-12.01–12.08 [Flood Protection Plans. Observed Flood Phenomena JEL-12.01–12.08]. KÖVIZIG [Körös Region Water Management Directorate].

Table 2: Distribution of flood protection phenomena per protection lines

Protection section number	Total length of phenomena occurred (57 years) (m)	Average total length of phenomena occurred (1 year)	Total number of phenomena occurred (57 years)	Average total number of phenomena occurred (1 year)
12.01	304,486	5,342	685	12
12.02	179,730	3,153	488	9
12.03	91,821	1,611	371	7
12.04	292,057	5,124	776	14
12.05	158,521	2,781	434	8
12.06	122,779	2,154	511	9
12.07	65,982	1,158	302	5
12.08	68,430	1,201	231	4

Source: 12.01.–12.8. KÖVIZIG árvízvédelmi szakaszok. Műszaki leírás [12.01–12.08 KÖVIZIG Flood Protection Sections. Technical Description] Körös Region Water Management Directorate

The table above (Table 2) shows that over the 57 years, more than 500 phenomena with high values have developed on the 12.04, 12.01, 12.06 defence lines, which means an average of 9–10 phenomena per year. By observing the length of the phenomena that have developed, it can be stated that phenomena have developed on the 12.01, 12.04 defence lines for a length of more than 5 km per year, which greatly weakened the defence lines and made defence more difficult.

Categorisation of the phenomena

The data on the phenomena was documented separately, using 5 different categories, as shown below:

- seepage in the embankment (seepage, stream, drenching)
- seepage outside of the embankment (spring water, subsoil seepage, footing seepage)
- wave action (protection against waves caused by wind)
- sand boil (hydraulic soil failure)
- levee break

Table 3 shows the distribution of the number of documented phenomena by categories per protection lines:

Table 3: Distribution of flood protection phenomena per protection lines

Phenomenon group	Flood protection line								Total
	12.01	12.02	12.03	12.04	12.05	12.06	12.07	12.08	
Number of seepages in the embankment	108	117	51	135	113	140	40	40	744
Number of seepages outside of the embankment	558	369	318	600	295	324	262	178	2,904
Number of wave actions	10	1	0	0	0	46	0	13	70
Number of sand boils	9	1	2	39	17	1	0	0	69
Number of levee breaks	0	0	0	2	9	0	0	0	11
Total	685	488	371	776	434	511	302	231	3,798

Source: 12.01.–12.8. KÖVIZIG árvízvédelmi szakaszok. Műszaki leírás [12.01–12.08 KÖVIZIG Flood Protection Sections. Technical Description] Körös Region Water Management Directorate

Table 3 above shows the number of types of phenomena that developed on the protection lines, where it can be shown that the number of leaks outside the embankment (water seepage, subsoil seepage, bedrock seepage) was the highest on each protection line. Observing the data series, it can be stated that the most phenomena developed on the protection lines 12.04, 12.01, 12.06.

The following table (Table 4) shows the distribution of the number of phenomena according to the length of the protective conductors.

Table 4: Distribution of flood protection phenomena by categories per protection lines

Phenomenon group	Flood protection line								Total (m)
	12.01	12.02	12.03	12.04	12.05	12.06	12.07	12.08	
Seepage in the embankment (m)	30,755	44,221	9,394	45,396	37,758	50,295	9,994	4,847	232,660
Seepage outside of the embankment (m)	269,737	135,358	82,425	246,395	119,400	58,923	55,988	61,169	1,029,395
Wave actions (m)	3,985	150	0	0	0	13,560	0	2,414	20,109
Sand boil (m)	9	1	2	150	1,363	1	0	0	1,526
Dike break (m)	0	0	0	116	0	0	0	0	116
Total	304,486	179,730	91,821	292,057	158,521	122,779	65,982	68,430	1,283,806

Source: 12.01.–12.8. KÖVIZIG árvízvédelmi szakaszok. Műszaki leírás [12.01–12.08 KÖVIZIG Flood Protection Sections. Technical Description] Körös Region Water Management Directorate

Table 4 shows the duration of the types of phenomena that developed on the protection lines during the 57 years, where it can be shown that on each protection line, the number of seepages outside of the embankment was the longest-lasting phenomenon, followed by seepage in the embankment, wave action, sand boil and dike break phenomena in the embankment. Observing the data series, it can be stated that phenomena that weakened the protection lines developed the longest on the 12.01, 12.04, 12.02 protection lines.

Examining the data, it can be seen that seepage outside the embankment accounts for the most documented phenomena, both in terms of number of cases and length.

The following graph below shows the danger and load of the protection lines as the specific average length of the flood protection phenomena per protection line. The specific average length is the average of the length of the phenomena developed so far and the quotient of the length of the protection line, expressed in percentage.

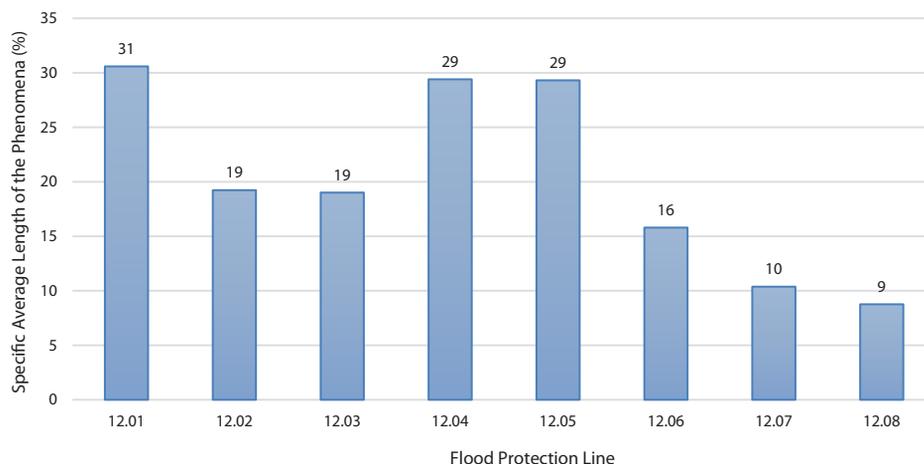


Figure 6: The specific average length of the phenomena occurring at the protection lines (%)

Source: Compiled by the author based on 12.01–12.08 KÖVIZIG árvízvédelmi szakaszok. Műszaki leírás [12.01–12.08 KÖVIZIG Flood Protection Sections. Technical Description] Körös Region Water Management Directorate

As shown in the chart (Figure 6), considering the already occurred phenomena, the protection line 12.01, i.e. the Hármás-Körös section is the most overloaded with its specific average length of 31%. This is followed by the 12.04 line of the Kettős-Körös and the Fekete-Körös section with 29%, then the 12.05 line of the Fekete-Körös and Fehér-Körös section with 29%.

The outlier value on the 12.01 line can be explained by the permanent floods (may last 2 to 12 weeks, with an average duration of 37 days) occurring on the Hármás-Körös (because of the backwater effects of the Tisza), during which several phenomena can develop since the flood greatly burdens the protection line.

On the 12.04. flood protection line, the soil properties of the embankment can influence the number of phenomena occurred (average duration of floods is 21 days). Contemporary records already confirm that a significant number of seepages in the embankment and subsoil have been developed on this protection line due to the saline soil of the embankment. This is also confirmed by the fact that this was the first section where a brick wall (Figures 7 and 8) was built into the embankment as a protection against seepage.

On the 12.05 protection line, many phenomena may develop due to the large water column formed as a result of increased flooding tendency (average duration of floods is 21 days).

The documented phenomena captured above weaken the stability of the flood protection lines (levees), thus endangering flood safety. Because of this reason, it is important to have a good protection against it.

Protection against such phenomena always require at least monitoring but may also involve intervention. In any case, this demands great human and material resources.

Protection against phenomena

There are two ways to protect against flooding: during the flood itself or learning from prior flood protection experiences. Flood protection efforts often comprise of the establishment of temporary protection facilities that help ensuring stability (during the water load period). These structures are usually dismantled after the flood. The need for such structures is later recorded and marked as flood protection experience. Learning from these experiences and scenarios helps to rationally design all the structures that are necessary to strengthen the dikes. Building these structures before a flood is developed one can avoid the recurrence of a critical flood phenomenon that would often require heroic human intervention. These structures can be built both in the embankment and possibly in the subsoil as well with the aim of increasing flood safety and mitigating flood risks.

The built-in flood protection facilities may be divided into two groups:

- active (limiting the harmful effects of water entering the seepage area to a tolerable level)
- passive (mitigating and/or preventing leaking water to penetrate the seepage area)

As far as their location is concerned, the flood protection facilities may be divided into the following categories:

- Structures built into embankments: the purpose of this is to actively or passively protect the area from the seepage process that occurs within the embankment.
- Structures built into the subsoil: the purpose of this is to actively or passively protect the area from the seepage process that occurs within the subsoil.

The following table (Table 5) demonstrates the distribution of built-in flood control structures:

Table 5: Built-in flood control structures

In the embankment		Subsoil	
Active	Passive	Active	Passive
Drainage system	Slurry wall	Relief well	Damping mat
Sand drainage layer	Sheet pile		Slurry wall
Stone drainage layer	Foil		Sheet pile
Drainage blanket	Cut-off wall		
Stone retaining wall			

Source: 12.01–12.08 KÖVIZIG árvízvédelmi szakaszok. Műszaki leírás [12.01–12.08 KÖVIZIG Flood Protection Sections. Technical Description]; Árvízvédelmi tervek. Észlelt árvízi jelenségek JEL-12.01–12.08 [Flood Protection Plans. Observed Flood Phenomena JEL-12.01–12.08]. KÖVIZIG [Körös Region Water Management Directorate]

The most common way of passive protection against seepage inside the embankment is the construction of a cut-off wall in the embankment, which can be either a brick wall, a slurry wall or even a sheet pile. These engineering solutions will be briefly presented below with illustrations.

Cut-off walls inside embankments

In an attempt to protect against seepage, flood protection facilities were built in embankments already between 1885 and 1914. This flood protection initiative included impermeable brick walls that were built into the right side of the embankment of the Kettős-Körös river. At that time, this was a novel solution that protected the area against the wetting and soaking of the saline soil and the embankment.⁸

The following figures show the current status of the exposed brick wall that was uncovered during the fixing of the embankment (Figures 7 and 8).

⁸ GÖG 1983: 7–8.



Figure 7: The right side of the embankment on the Kettős-Körös between 18 + 350 – 18 + 650 tkm
Source: compiled by the author



Figure 8: The right side of the embankment on the Kettős-Körös between 18 + 350 – 18 + 600 tkm
with the exposed brick wall
Source: compiled by the author

Self-hardening slurry wall

When creating (Figure 9) a self-hardening slurry wall, a rift is made with a scraper chain in which the binding agent is delivered into the different depths of the planned slurry wall either by gravity or by injection. It is then mixed with the soil and solidifies into a self-hardening slurry wall. This type of wall helps preventing seepage.



Figure 9: Building a slurry wall on the embankments of the Hármas-Körös
Source: Körös Region Water Management Directorate

Sheet pile wall

The sheet pile walls – put down with hydraulic sheet piler one after another – prevent water seepage both in the embankment and the subsoil (Figure 10).



Figure 10: Construction of the sheet pile wall at the toe of the dyke and embankment of the Hortobágy-Berettyó river system
Source: Körös Region Water Management Directorate

Drainage systems (infiltration galleries)

The drainage system is a method of active protection against seepage, which collects the water leaking through the embankments at the toe of the dyke on the protected side of the embankment. The water is then directed into the seepage canal.

When the purpose of the system is to drain the water out of the subsoil, the structure is called a gallery (Figure 11).



Figure 11: Construction of a drainage system at the toe of the dyke on the protected side of the embankment on the Fekete-Körös river

Source: Körös Region Water Management Directorate

Relief well

A pressure relief well (Figure 12) is a protected side tapping system that lowers the seepage pressure loss line by removing water seeping through the subsoil due to flood column pressure, thereby reducing the buoyancy force on the protected side to a tolerable (non-hazardous) level and thus significantly reducing hydraulic fracturing.



Figure 12: Relief well at the protected side forehead on the Fehér-Körös river

Source: Körös Region Water Management Directorate

The installation status of the aforementioned flood protection facilities on the protection lines managed by the Körös Region Water Management Directorate are described in the following table (Table 6).

Table 6: Installation status of the flood protection facilities by categories per protection lines

Number of flood protection facilities per protection line									
Category	12.01	12.02	12.03	12.04	12.05	12.06	12.07	12.08	Total
Passive protection in the embankment	48	11	4	14	2	2	1	7	89
Active protection in the embankment	8	9	10	16	4	11	2	3	63
Passive protection in the subsoil	0	0	0	3	0	1	0	0	4
Active protection in the subsoil	0	1	0	5	0	0	0	0	6
Total	56	21	14	38	6	14	3	10	162

Source: Árvízvédelmi tervek. Észlelt árvízi jelenségek JEL-12.01–12.08 [Flood Protection Plans. Observed Flood Phenomena JEL-12.01–12.08]. KÖVIZIG [Körös Region Water Management Directorate]

The most commonly applied method of protection against seepage is passive protection, which accounts for 89 of the 162 structures (slurry walls, sheet piles, foils and cut-off walls), the combined length of which is also the largest.

The categorisation of the built-in structures per protection lines are described in the following table (Table 7).

Table 7: The categorisation of built-in structures by protection lines

Category	Length of flood protection facilities (m)								Total
	12.01	12.02	12.03	12.04	12.05	12.06	12.07	12.08	
Passive protection in the embankment	8,352	3,488	4,290	4,640	184	741	233	1,362	23,290
Active protection in the embankment	2,479	5,215	5,325	7,485	526	4,889	179	313	26,411
Passive protection in the subsoil	0	0	0	340	0	85	0	0	425
Active protection in the subsoil	0	86	0	1,093	0	0	0	0	1,179
Total	10,831	8,789	9,615	13,558	710	5,715	412	1,675	51,305

Source: *Árvízvédelmi tervek. Észlelt árvízi jelenségek JEL-12.01–12.08 [Flood Protection Plans. Observed Flood Phenomena JEL-12.01–12.08]. KÖVIZIG [Körös Region Water Management Directorate]*

Summary

The flood protection embankments of the Körös region are gradually exposed to the soaking effect of the floods during each event. The consequences of these phenomena include, among others, hydraulic soil failure and the reduction of the shear strength of the bound soils affected by seepage to a critical extent resulting in loss of stability (slope slide, levee break).

In addition to the weather conditions (precipitation and temperature), the extent of seepage is also heavily dependent on the water level as well as the duration of the flood wave (number of days spent under flood).

This article focused on the presentation of data collected on flood phenomena since 1969 until today, with special attention to the built-in flood protection facilities, the length and number of occurrences, the protection lines and the rivers as well. It is noteworthy that – based on the length of both the built-in structures and the phenomena – there are still several locations and sections along the protection lines that require intervention.

In order to determine the necessary improvement opportunities, it is recommended to carry out a practical and statistical study regarding the occurrence of flood phenomena on each protection line in question. During the study, experiences gained from the previously built-in stability enhancing structures should also be taken into consideration.

When planning these interventions, seepage tests and stability models may be carried out, leveraging the characteristics and geomechanics data of previously observed flood phenomena. Based on the evaluation of prior experiences, such studies will result in a more realistic and economical safety enhancement.

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Robots on the Battlefield

István BODNÁR¹ 

Robotic systems are revolutionising modern warfare, with applications ranging from reconnaissance and bomb disposal to autonomous combat and logistics. While these technologies reduce human casualties and enhance operational efficiency, they raise critical ethical and legal questions about accountability, autonomy, and the future of human-soldier roles. Robots are ideal for use in military operations because they can perform such tasks that are too dangerous for humans. Robots can be used to traverse dangerous terrain, locate and eliminate threats, and support and supply troops on the ground. They can also be used to protect troops from enemy fire and can serve as decoys to draw fire away from troops. In addition, robots can be used to provide intelligence and real-time information on the battlefield that can be used to make strategic decisions. This paper examines the evolution of military robotics, analyses current battlefield applications, and evaluates the moral challenges posed by autonomous systems, advocating for urgent regulatory frameworks.

Keywords: *battlefield, robots, drones, embedded systems, industry*

Can we credit Heron of Alexandria with the invention of combat robots?

The first written source of self-moving applications can be tied to the ancient Greek mathematician and engineer Heron of Alexandria. To be precise, it is the Aeolipile, which was an early steam-powered rotating machine, and the first programmable humanoid robot, the Mechane.² Even if not directly, this was the first historical example of a device that operated independently of human power. From today's perspective, technological developments were not particularly noteworthy in Heron's time; rather, they excelled in philosophy and religion, political and legal institutions, poetry and drama, and in the realm of scientific speculation.³ That is why we had to wait for a while for revolutionary changes, but in the meantime, thanks to the technological and subsequent industrial revolution processes, many surprising and strange inventions saw the light of day. Barely 2,000 years after Heron's time, not only in the minds of science fiction writers such as Isaac Asimov,

¹ OF-2, PhD student, Ludovika University of Public Service, Doctoral School of Military Engineering; telecommunication engineer, Rheinmetall, e-mail: drotposta@bodisz.hu

² NORMAN 2014.

³ BUCHANAN s. a.

but also in industrial equipment, steam-powered mechanical instruments and autonomous electrical devices, which we can call robots, appeared. The first combat robots were generally and basically used for remote-controlled reconnaissance operations, although some were designed for offensive operations. As technology advanced, the capabilities of combat robots have become more sophisticated and versatile. Today, combat robots are used for a variety of purposes, including reconnaissance, search and rescue, surveillance, and increasingly for combat purposes.

The aim of the research

This study employs a multidisciplinary approach to analyse three key dimensions of military robotics: basic terminology of robotics, technological advancements, ethical dilemmas in deploying lethal autonomous weapons. Case studies from NATO, Israel and Russia are the basis of the analysis in real-world applications.

As one of the key dimensions of the paper, it covers the legal and ethical aspects of military robotisation. This includes ethical issues in the use of autonomous weapon systems, an examination of international legal regulations. The research aims to contribute to a comprehensive understanding of the military applications of robotics, while highlighting the future directions and challenges of the field in modern warfare.

About robots in general

The term ‘robot’, derived from the slavic *robota* (forced labour), entered popular lexicon through Karel Čapek’s 1920 play *R.U.R.*, foreshadowing their role as substitutes for human labour.⁴ Today, military robots extend this concept, performing tasks deemed too dangerous, precise, or logistically complex for soldiers.

Although some early literature explains the concept of robots as if they were perpetual slaves, is this the present picture in this sector? Firstly, if we look at today’s market, we can see many commercial robots. Next to Japan, Switzerland⁵ is the biggest manufacturer of these products that mainly serve industrial purposes, but Japan is also a leader producer of the entertainment electronic devices for people. The most widespread are the very useful vacuum cleaner robots and the flying robots or drones of which the most spectacular are quadcopters. These products are the cheapest and are the most popular and, in many cases, the most frequent users of these techniques are the former airplane model makers who often set up wireless cameras in these machines.

Secondly, in factories many human workers have been replaced by industrial robots mainly in operations where semi-skilled workers made a portion of the assembly line and where highly precise work was required. These factories are where most of the electrical gadgets, automobile parts and food are produced. In these plants, of course, not

⁴ ČAPEK 2013.

⁵ OWEN-HILL 2021.

just individual work operations are automated but the whole workflow is robotised and coordinated by a central system. The applications are using enormous IT architectures in the background such as servers, BigData structures and many-many Internet of Things (IoT) components.

The third biggest area is the military industry where many questions about robotics arise. How can we integrate robot technology into the battlefield? How does it change the art of warfare? Are robots as smart as humans? Could this technology be more effective than human warriors? What are the benefits of substituting the soldier in the battlefield? Based on my scientific research, I have concluded that industrial devices operate using the same processes and IT architectures, but work with different data, and their appearance in cyberspace and physical space differs.

What are robots?

The different applications of robots could fill several books, therefore in this section I would like to give a general overview of the different names of robots and their characteristics.

As technology advances, understanding the distinctions between these robotic systems is crucial. While there can be overlap and hybrid solutions, recognising the specific characteristics and purposes of each type helps in accurately discussing and applying robotic technologies.

Renowned robotics expert George Bekey defines a robot as a device that combines sensing, cognitive processing and action. In essence, a robot must possess:

- sensors to perceive its environment
- processing capabilities that mimic certain cognitive functions
- actuators to interact with its surroundings

From a cultural perspective, robots are often envisioned as mechanical entities that display human-like abilities and behaviours. This popular conception aligns with Bekey's technical definition, emphasising the blend of perception, decision-making and physical interaction that characterises robotic systems.⁶ Think about C-3PO from Star Wars or the Terminator. While this pop-culture image emphasises humanoid forms and sentient behaviour, real-world robotics prioritises function over form. For example, autonomous drones or warehouse sorting bots may lack a “face” or “limbs”, but they excel at specialised tasks through advanced perception and decision-making.

Summarising, devices that can only perform preprogrammed operations under human control may not necessarily qualify as robots. Additionally, the term “droids” is a fictional concept popularised by science fiction, while “co-bots” is a commonly used term for collaborative robots that work alongside humans. Sometimes we find sources that refer to droids as androids, which is a term for humanoid robots, or they are also referred to as droids.⁷ Just to mention movies, we see cyborgs, human-based robot hybrids, but in reality,

⁶ BEKEY 2017.

⁷ KHILLAR 2018.

we already have medical devices such as touch-sensitive limbs, which unfortunately are not as high-tech as the devices we know from famous pop culture movies, so in real life, cyborgs are not the same as what we see on screen.

My own theory: From industry to the battlefield

In the past, when we spoke about robots, people generally imagined large, motor-driven machines or analogue devices with basic functions, but nowadays the highly developed microchip and embedded systems give new meaning to these instruments. Thanks to advancements made by developers, electrical parts have undergone miniaturisation, resulting in various improvements such as increased efficiency, lower power consumption, and faster processors and sensors. This has allowed these gadgets to become more than simple robots.

As a result, we can cram formerly unimaginable applications in small embedded systems and thanks to it we can create previously unseen structures. With the help of these advancements, we can create systems what can collect, transmit, process and evaluate information immediately from multiple aspects of the industrial production line and according to my theory we can simply just transform the procedures of these sustainable and human-centric Industry 5.0⁸ solutions to be applicable in operational areas.

Industrial examples allow us to learn about many of the rules of the mature model, such as the cooperation between robots and the human “interface”, which fully meets the expectations of modern warfare. Generally, it can be said that the implementation of autonomous systems used in factories and military equipment is different, but their direction of use is the same. In light of this, we can see some examples of how the industrial environments can be adapted for use in the field.

Thus, in addition to commercial and industrial applications, one of the largest areas is the military sphere, where many questions arise regarding the use of robotics. How can we integrate robot technology into the battlefield? How does it change the art of warfare? Is it as smart as a human? Could this technology be more effective than that of the warrior? What are the benefits of substituting the soldier in the battlefield?

Comparing the industrial and battlefield robots, both are used to perform tasks that may be dangerous or too difficult for humans to do. Industrial robots are used in a variety of settings including manufacturing, assembly and construction, to automate and streamline processes. Battlefield robots, on the other hand, are used on the battlefield to reduce the need for human personnel in dangerous situations. Robots can operate autonomously and make decisions without human intervention, allowing them to respond to threats and protect soldiers without risking lives. Both types of robots are typically equipped with sensors and cameras, allowing them to gather data and detect obstacles. Additionally, both industrial and battlefield robots are able to operate autonomously, meaning that they can be programmed to make decisions without constant human supervision.

⁸ European Commission 2022.

Applying robots to the battlefield is a huge breakthrough because it changes the strategy of the assault and the preparation of the war to a great extent. Firstly, we could make movements much safer because the main face of our motions are the robots. They can help warriors to gain more information about the battlefield such as place positioning and clarification, reconnaissance, with guarding the user's personal safety. In fact, in the real world, we could achieve greater efficiency by thinking in terms of systems such as connecting all our reconnaissance robot systems to our satellite communication system and collecting all the information in a common database so that we can identify our forces and all the gained information about the enemy and neutral powers. If we follow this path, then in certain cases our soldiers could control movements from their chairs far away from the battlefield, and maybe someday we could even create a fully automated, unmanned cyber warfare system.

Construction of the robots

Nowadays, robot construction is based on several twenty-first century technologies. First of all, the creators have to design the Kinect of the robots in a CAD/CAM design software, then prepare every component of the robots, and finally manufacture them using additive manufacturing technologies such as 3D printing for testing.⁹ Meanwhile the electrical engineers have to design the digital circuits together with the microchip programmers.

There are several components that go into creating a robot, depending on its intended use. The most important components of a robot include the body, the control system, the motor, and the sensors and actuators. The body is typically made from a sturdy material, such as aluminum or steel, that can withstand the rigors of the environment in which the robot will be used. The control system manages the robot's functions and enables it to interact with its environment. The motor is responsible for the robot's movement, and the sensors and actuators allow the robot to perceive and interact with its environment. Finally, the robot must be tested and calibrated to ensure that it is performing optimally.¹⁰

Generally, the robot software is the most time-consuming part of the entire process, as software engineers must write numerous software exception handlers in low-level languages, primarily Assembly or C. Many companies offer embedded boards or multifunction microchips and the result depends on the designer's work.¹¹ Especially for military demands, a few manufacturers offer special military grade microchips but at the end of the production process the designers have to plan the whole device with such materials that meet the military requirements.

⁹ KUHN 2016.

¹⁰ RUNDLE 2014; SANDIN 2003.

¹¹ BARR-MASSA 2006.

Battlefield application of the robots

Let us examine the potential advantages of utilising robots, or collaborative robots (co-bots), within military operations. I have mentioned above the main purpose of networked cooperation with robots and remote-controlled or fully automated systems. These are very important if we want to protect our soldiers. In many countries economists debate whether it is cheaper to train soldiers or to build more expensive, high-tech machines. In this discussion I would like to strengthen those parties who vote for the machine building because in no way could we measure a human life with the value of a machine. Application of the robots on the battlefield can reduce casualties on both sides of the conflict and they are also cheaper and more efficient than humans for many tasks. They require fewer resources to operate and can be programmed to perform tasks quickly and efficiently, reducing the need for staff. I guess it is not an economic but rather ethical question. Based on classical studies, we know that an injured soldier requires more logistical support than a robot that has been fired or destroyed. So, using co-bots we can guarantee the safety of our soldiers, they can be deployed quickly and easily, allowing operations to be carried out quickly and without complex logistics. This can significantly reduce the time required for missions and increase the efficiency of operations.

Robots are very useful and helpful on the ground but of course they will never replace humans, meaning a robot will never be able to conduct a hostage negotiation, assess a battlefield injury, lead an assault, or decide between friends and enemies because there are situations where the human presence is necessary; however, these gadgets can facilitate victory on the battlefield. On the other hand, there are many cases when these machines could be used more effectively than humans because they can be deployed much more quickly, consume less energy and pose less danger to human life.

Let us examine which countries are developing different types of robots, without attempting to be exhaustive. Robots come in many forms and are used in many areas. Some countries use these unique technologies for very specific reasons. In European countries, the most common are Explosive Ordnance Disposal (EOD) robots, which have been used by soldiers since the Second World War to locate explosives hidden underground. For example, even today nobody lives in the area of the Verdun Forest in France because there are so many active explosive devices underground, and French EOD teams still use their robots to clear the area and remove the hidden explosives. These robots are also common in mission areas where terrorists use improvised explosive devices (IEDs).

NATO uses a very complex Missile Defence System, whose launch and detection systems are partially automated and operate with digital circuits, making it a kind of robotic system. Maybe in this dangerous political situation, a fully automated system that malfunctions close to the Russian border could cause unfortunate diplomatic problems. The reason why I started with the NATO system is that Israel has also made its own self-defence air missile system, which is integrated into the Iron Dome system that is fully automated and does not require a human operator, only system supervision and maintenance. This system is very useful against missile attacks, which are very frequent in the area. According to new information, the system is now even more effective as Israeli

engineers have begun replacing all missile launchers with high-energy laser beams so that they can destroy artillery missiles from a distance of up to 7 kilometres.¹²

During the Cold War, nuclear weapons posed the main threat, but today, the production of war robots has also come to the fore in Russia. I could not get enough information about Russian robots because the sources were in Russian, but I was able to watch some videos about the Russian Army Expo (RAE) in the English-language media, where some very serious robots with guided and remote-controlled firing systems were presented. One of these is a self-propelled Kalashnikov, but the video did not reveal whether these systems had been approved for use by the Russian Army.¹³

Examples of battlefield application

Advanced robotics are being used by modern militaries more and more to improve tactical capabilities, lower human risk, and obtain strategic advantages. Below are a few of the most noteworthy instances of battlefield robotics in operation, ranging from unorthodox designs to extensively used systems.

*Reconnaissance snake robot (Israel)*¹⁴

Israel's camouflaged snake robot, a covert reconnaissance instrument that imitates biological snakes, is among the most inventive designs. At two meters in length, it mimics the slithering motions of an actual snake, allowing it to slither through tight spaces, scale barriers, and sneak into dangerous environments without being noticed. It can relay voice and video data over 5–6 km thanks to its high-resolution cameras, audio sensors, and real-time transmission capabilities. In addition to surveillance, this robot also functions as a “suicide snake” by carrying explosives to destroy valuable targets, like enemy weapons or fortified positions, without endangering the lives of soldiers. Because of its versatility, it is perfect for counterterrorism and urban warfare.

Neutralising explosive threats: EOD robots

One of the most prevalent and useful weapons in contemporary warfare are EOD robots. Modern systems like the TALON or PackBot integrate sophisticated manipulator arms with human-like dexterity, whereas early models concentrated on simple tasks like moving explosives or cutting wires. Using instruments like X-ray scanners, disruptors and precision cutters, operators remotely operate these robots to disarm complex IEDs or

¹² RUTMAN 2021.

¹³ MIZOKAMI 2017.

¹⁴ NBC News 2009.

UXO in real time. Modular payloads are another feature of some high-end models that let technicians switch out tools for different situations. These robots, which have more than 50 documented disarming techniques, are essential for reducing casualties during bomb disposal operations.

Quadruped logistics support: Boston Dynamics' BigDog and WildCat¹⁵

BigDog: This quadruped robot, standing one meter tall, can carry up to 100 kg of cargo (such as supplies or equipment) over rocky, muddy and snowy terrain. Even after slipping or being shoved, it can still walk, run and climb thanks to its dynamic stabilisation system.

WildCat: With a top speed of 32 km/h, WildCat is the fastest quadruped robot. It combines speed and agility to avoid obstacles and change directions quickly. Both robots follow soldiers on their own, which eases their physical strain while on missions. Subsequent versions might incorporate combat payloads or surveillance.

Drones and UAVs: From reconnaissance to combat

Platoon-level reconnaissance, GPS mapping and the delivery of vital supplies (like medical kits) are all made possible by smaller drones, such as quadcopters like the PD-100 Black Hornet. They are perfect for stealth missions because of their small size and silent operation.¹⁶

Long-endurance platforms with missiles, laser-guided bombs and high-resolution sensors are provided by larger UAVs such as the MQ-1 Predator and MQ-9 Reaper. The Predator, for instance, can loiter for 24 hours at speeds of 220 km/h, delivering real-time intelligence and precision strikes.¹⁷ These systems allow for “over-the-horizon” engagements with little risk to personnel because operators operate them remotely, frequently from continents away.

Future trends: Swarm robotics and AI integration

Inspired by the collective behaviour of insects, birds, or fish, swarm robotics has the potential to completely transform military operations. Swarms, as opposed to single-robot systems, use emergent intelligence, redundancy and decentralised coordination to accomplish challenging tasks. These systems work especially well in electronic warfare, distributed surveillance and saturation attacks. Two innovative swarm robotics applications are shown below, along with technical details and documented use cases.

¹⁵ Legacy Robots s. a.

¹⁶ FAHLSTROM–GLEASON 2012.

¹⁷ U.S. Air Force s. a.

Perdix Drone Swarm (U.S. Department of Defense): Using Perdix, an autonomous, AI-driven micro-UAV, the DoD demonstrated one of the biggest micro-drone swarms to date in 2017. Three F/A-18 Super Hornets launched 103 Perdix drones in mid-air during a test in California, and the drones self-organised into a unified swarm to carry out a mock reconnaissance mission over a disputed area.

Turkey's Kargu-2 Kamikaze Drone Swarm:¹⁸ During the 2020 Libyan conflict, one of the earliest known instances of AI-driven swarms being employed in combat was a loitering munition created by STM. A UN report claims that without direct human supervision, a swarm of Kargu-2 drones tracked and attacked fleeing enemy forces.

Legal questions

We should mention the legal implications of robot application in the battlefield. What is happening if a robot kills an innocent person or just simply does harm to an estate or a property? Who is guilty in these cases? What happens when a terrorist or insurgent group equip themselves with autonomous weapons?¹⁹ Do we know the concept of robot ethics? Robotics ethics refers to the study of ethical considerations related to the design, construction, use and treatment of robots. It is concerned with how humans interact with robots and how robots can be designed to behave ethically. In other words, robotics ethics explores the moral implications of our interactions with robots. A possible answer to the above questions may be provided by a study that states that there are no such current laws in any of the previously mentioned countries. The current position is based on human moral values, as it states: "The final part counters objections that responsibility for Lethal Autonomous Robot System (LARS) killing in war automatically lies with the software programmers, politicians and military commanders."²⁰ According to the legal approach, when a robot kills an innocent person or causes damage to property, the jurisdiction where the incident occurred determines who is liable. In some cases, criminal or civil liability may be assessed against the robots' owner, depending on the type of harm or damages caused. Additionally, the extent of damages that the robot's owner may be liable for may be limited by the terms of any contract that governed the owner's use of the robot. Civil liability may also apply in situations where a robot causes harm to a property.²¹ Generally speaking, if the robot's owner was found to be negligent in their use of the robot, then the owner may be liable for any damages caused by the robot.

Through my argumentation above, I have tried to point out that international law struggles to address autonomy in warfare. Article 36 of the Additional Protocol I to the Geneva Convention mandates review of new weapons,²² but autonomous systems like the STM Kargu-2 (used in Libya with alleged AI-targeting) operate in legal gray zones.

¹⁸ NASU 2021.

¹⁹ DAWES 2021.

²⁰ ROFF 2013.

²¹ ANDERSON-WAXMAN 2012.

²² BOULANIN 2015.

Directive 3000.09 of the U.S. Department of Defense²³ requires “appropriate levels of human judgment” over lethal decisions, yet fails to define “appropriate”. The best example for this exploited loophole is in contested zones like Ukraine.

Summary

To summarise all the robotic technologies, we find them very useful on the battlefield, but many of them are immature at the current stage of development. In the future, warfare and battlefields will change significantly due to the expected proliferation of robots. New techniques have emerged on the battlefield thanks to developments over the past decades, as my basic research shows. Companion robots are becoming an even more integral part of the battlefield, and it is only a matter of time before these machines are advanced enough to be deployed in combat situations. As technology advances, the capabilities and potential of robots and robots on the battlefield will only continue to grow as the theory of my basic research also shows; Industry 5.0 solutions were placed to the operational area from the factories.

The military landscape is undergoing significant transformation with the increasing integration of robotic technology. These machines offer numerous advantages, including the reduction of human casualties and enhanced operational efficiency. As technological advancements continue, robots are expected to assume more sophisticated roles and execute increasingly complex operations in combat scenarios. Consequently, the nature of warfare is rapidly evolving, driven by the deployment of various robotic entities, including collaborative robots and humanoid machines, on the battlefield. The Cold War led to the war on terrorism expanding into the digital realm, resulting in hybrid warfare. In this new form of conflict, the primary display of strength is no longer the traditional method of amassing troops for mutual deterrence. Instead, it involves the utilisation of cutting-edge weaponry to acquire power. Although these advanced weapons may initially prove effective, countermeasures will inevitably be developed. The most significant threat to these sophisticated robotic systems comes from hackers, necessitating our adaptation to this aspect of modern warfare. Future generations will witness the dramatic transformation of our approach to armed conflict.

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²³ Department of Defense 2023.

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