Constructive Simulation System Developments in Hungary

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Abstract:

In Hungary, the Zrínyi 2026 Home defence and force development program, and the Irinyi industry development plan defined the defence industry as one of the national strategic industries.
In Africa, the management of local and inter-country conflicts, economic problems, livelihood crises caused by climate change, terrorism and migration require prepared military, law enforcement and disaster management organizations. The efficiency of training could be significantly increased by the introduction of modern simulation tools, these countries are just at the beginning of this transformation. Hungary has significant national capabilities in the field of constructive and virtual simulation training solutions. Over the past 30 years, new, cost-effective solutions have been developed, the Hungarian solution becoming even more economical and flexible, available for more price sensitive customers too. The present study summarizes the current work on the Hungarian constructive simulation system, as well as the requirements expressed by current and potential users (even from the African continent) and the development plans.

Keywords:

Military-, law enforcement-, disaster management simulators, Constructive CAX simulation, Africa, local and inter-country conflicts, KRONOS, MARCUS.

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Introduction

In Africa, local and inter-country conflicts, economic problems, livelihood crises caused by climate change, terrorism and migration constitute a major challenge to national governments, international organizations and some of the countries concerned. Managing these problems would require prepared military, law enforcement and disaster management organizations. The efficiency of training of the responsible personnel could be significantly increased by the introduction of modern simulation tools. International trends clearly point to the further expansion of simulation training, for both financial and professional reasons. The African continent is apparently only just at the beginning of this transformation, only two countries known to have a constructive simulation system in place. However, recognition has taken place in several countries, in Hungary the developer faced several enquiries in recent years about the Hungarian-developed system.

In Hungary, due to the ongoing procurements, the acquisition, commissioning and integration of additional simulation systems are expected. Hungary has significant national capabilities in the field of constructive and virtual simulation training. The MARCUS[2] constructive simulation operates in the Simulation Centre of the Hungarian Defence Forces (HDF) in Várpalota and in several garrisons, which ensures the full service of staff training. Over the past 30 years, more than 20 domestic developments have supported training, cost-effective solutions have been developed, operation, maintenance and further development have become even more economical and flexible. The present study summarizes the current work on the Hungarian constructive simulation system (MARCUS), as well as the requirements expressed by current and potential users and the development plans.

Requirements for the operation of a modern CAX[3] system nowadays

The simulators can be divided into 3 main groups: live, virtual and constructive. (Cayirci and Marincic, 2009) HDF uses all three main simulator types for training.

Live simulators support real-world and field-based exercises, e.g. MILES[4].

Virtual simulators are tools for individual or small subunit training. A very wide range of such training simulators, flight, driving and tactical simulators can be found among the international training systems. Examples in Hungary include the Gripen pilot training simulator, JTAC[5], which also performs international training tasks, the recently installed Thales helicopter crew training simulator, and the KRONOS[6] platoon level virtual tactical simulator deployed in several garrisons and has been used for many years.

[2] MARCUS: Constructive CAX simulation
[3] CAX: Computer Assisted Exercise
[4] MILES: Multiple integrated laser engagement system
[5] JTAC: Joint Terminal Attack Controller simulator
[6] KRONOS: Platoon level reconfigurable virtual simulator

Constructive simulation systems are used for commander and staff training, typically for company, battalion or brigade levels, and for military education. For that purpose, the MARCUS simulation system has been deployed in Hungary. The centre was set up in Várpalota, in the Simulation Training Centre of the Bakony Training Centre of the Hungarian Defence Forces, while smaller simulation systems (MARS[7] / MARCUS battalion) operate in several garrisons of HDF and the National Civil Service University (NKE). These systems are able to operate separately or in a networked mode using a unified virtual battlefield.

In Hungary, the development tasks and schedule of the national constructive simulation system (and the modernization of simulation training in general) must be aligned with the goals set by the Zrínyi 2026[8] force development program.[9] This requires the formulation of general requirements for constructive simulation systems.

The following main requirements can be established against a state-of-the-art CAX system:

For the training audience, role player and exercise controller staff:

- The simulation should ensure that CAX exercises are held for practicing commanders and their staff, including preparation, planning, execution, and after-action reviews.
- Even multi-level exercises could be executed featuring companies, battalions, brigades, and divisions.
- The simulation environment should ensure the preparation of the training audience for the practice of NATO[10] procedures and the development of interoperability.
- The simulation should support the execution of multinational exercises.

In relation to units and subunits included in the simulation:

- Corps / division level simulation should be performed mainly by handling company level aggregated subunits in the entire area of operation.
- Being able to handle (display and model in detail) selected units of simulated forces at the elementary unit (entity) level.
- Being able to work with mixed resolution entities (elementary units and aggregated subunits can be present at the same time, in one scenario).

[7] MARS (Marcus/b): Battalion level constructive simulation
[8] Zrínyi 2026: Home defence and force development program
[9] Other European countries have launched similar programs due to various threats and challenges. More about these: Ilchenko, O., Brusakova, O., Burchenko, Y., Yaroshenko, A., Bagan, Y. 2021. The role of a defence industry in the system of national security: a case study. Entrepreneurship and Sustainability Issues, 8(3), 438-454. http://doi.org/10.9770/jesi.2021.8.3(28) and Dubauskas, G., 2021. Conditions influencing the change of defense budgets - the case of Lithuania. Insights into Regional Development, 3(2), 282-288. http://doi.org/10.9770/IRD.2021.3.2(8)
[10] NATO: North Atlantic Treaty Organization

- Tactical situations should be allowed to include any organizational structure, vehicle and weapon characteristics, deployment positions on the battlefield, both for own forces and for the opponent and other participants, and these could be easily and freely modified by the scenario planner according to training needs.

Regarding the modelled activities:

- A state-of-the-art constructive simulation should model traditional and urban combat, combat support, fire support, air support and air defence, naval warfare, reconnaissance, logistics, CBRN[11], electronic and cyber warfare, operation other than war/OOTW[12], peace support, stability operation, disaster management, critical infrastructure protection, counter-terrorism and border management in high detail. As can be seen, a state-of-the-art constructive simulation system is capable of fully modelling the African problems mentioned in the introduction, and can support the preparation and training effectively.

Regarding the tactical database:

- The tactical / technical database should contain detailed technical data and capabilities of the most commonly used military equipment in NATO and non-NATO countries.
- The tactical / technical database should be modifiable and expandable by the user.
- Non-combatants and civilians should be able to appear in the simulation.

Regarding the modelled battlefield:

- The basic model of the virtual battlefield is the digital terrain database, which consists of a raster terrain model and a detailed, high-resolution vector overlay of terrain features / maps. The terrain database can be extended from various types of standard (NATO and non-NATO) format databases from anywhere in the world to be suitable for modelling any area of operations. Being able to use the OpenStreetMap[13] database for training. A huge advantage of the free OSM is its almost complete coverage of the globe, even for Africa.
- The digital terrain database can be supplemented with additional standard format raster layers, aerial photographs, satellite images, scanned maps.
- The modelling should take into account the characteristics of the battlefield and the terrain features on it, the environmental effects: light conditions, wind, rain, snow, temperature, including extreme conditions (desert, high mountain), the latter being particularly important for an application in Africa,
- The properties of the modelled terrain may change as a result of events in the simulation execution (dynamic terrain).

[11] CBRN: Chemical, Bacteriological, Radiological, Nuclear
[12] OOTW: Operation Other Than War
[13] OpenStreetMap is a world map database available under a free license.

- Different types of engineering obstacles should be modelled.
- Modelling should be based primarily on physical algorithms.
- The model should deal with human factors (e.g. qualifications, suppression, recovery, fatigue, training level, etc.)
- The modelling should take into account random errors, failures, standard deviations.

Regarding the design, execution and management of the simulation:

- The simulation should have a familiar, user-friendly user interface (based on the Windows operating system in Hungary).
- APP-6[14] Military Symbology on the high-resolution, digitised, vector and raster maps should be used; and the layers created by the training audience could be freely turned on and off.
- The user interface could be customized to each operator's task (displaying only the necessary interface elements and functions) for easier training and operation.
- The user interface should include intuitive functions that support the work of the role players / operators by offering possible user operations.
- Help should be provided with developing training scenarios with its extensive features. Assist the planning by displaying the results of computer-assisted terrain assessments (visibility, trafficability, terrain coverage, terrain section, etc.).
- Assistance with implementation using simple automatisms (e.g., route tracking for marching columns, performing planned activities, etc.).
- Inclusion of an extendable task archive.
- The simulation should be able to handle pre-planned events (MEL/MIL[15]) that affect the execution of exercises automatically or with the help of the directing staff/exercise controllers.
- Workstation user interfaces can be set to different languages individually.
- Being able to handle any user-defined workstation subunit binding, allow it to be changed dynamically during the simulation execution.
- It should be possible to create pre-planned activities, activity chains, their automatic execution and timing.
- It should be possible to request a simple 3D display of the terrain and the terrain features and tactical equipment on it from any point of view depending on the role of the operators, or the simulator should be able to connect to a different special 3D display device via a standard interface.

[14] APP-6 - Allied Procedural Publication 6, NATO Joint *Military* Symbology
[15] MEL/MIL: Master Events List/Master Incidents List

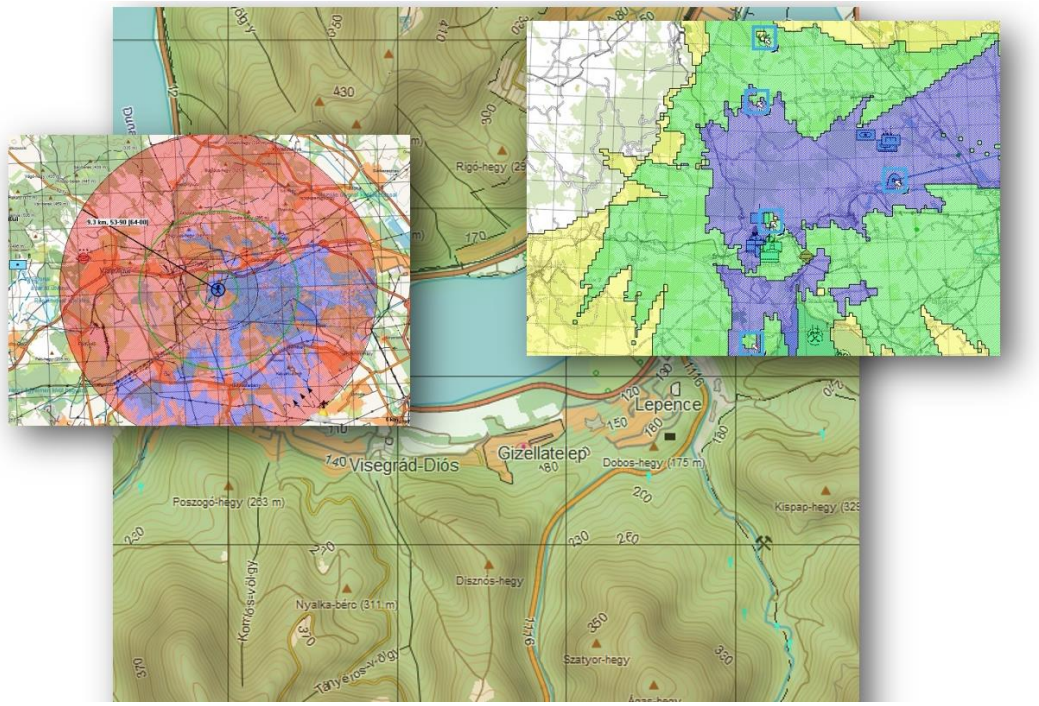

Figure 1. A terrain assessment in MARCUS simulation (one from many: Cross-Country-Movement). (Source: http://www.artifex.hu/hu Accessed 19 February 2021.)

Regarding the Evaluation of the Simulation Execution (AAR[16]):

- The simulator should have a built-in AAR system that provides detailed backup of exercises, its replay, and event search.
- It should be possible to query various statistics (e.g. stock changes, losses) from the saved data in the AAR system in tabular and graph format.
- The exercise could be restarted or a new exercise could be started from any saved state of a previously performed exercise

Regarding the connection to own systems:

- The simulation system should be suitable for distribution, can be installed in national dispersed locations.
- Systems installed in garrisons or other locations should be able to operate independently, without a central system, or in any combination, and perform exercises in a common virtual space. The connections should not require more than the standard internet bandwidth.
- There should be a configuration support function for connecting several systems, e.g. pre-planned workstation allocations.

[16] AAR - After Action Review

- If several systems are connected, the status of the connections can be monitored on the central system.

Regarding the exchange of data with other systems:

- Being able to connect to other simulation or control systems via standard NATO data protocols (HLA, ADatP-3[17], C2SIM[18]).
- Being able to connect to classified networks or systems.
- Enabling data exchange with perhaps the two most common NATO IT systems: LOGFAS[19] and TOPFAS[20].

Figure 2. MARCUS-KRONOS connection using HLA interface. (Source: http://www.artifex.hu/hu Accessed 19 February 2021.)

Regarding training necessary to operate the simulation system:

- Operator-level handling of the simulation should be taught to military users with relatively short training so that they can effectively use the user interface independently. To this end, the user interface should be customizable for each workstation.
- Enhancing the effectiveness of training operators, the system should include educational support functions and connect to an e-learning system (at least to the framework used in NATO).

[17]ADatP-3 - Allied Data Publication 3, NATO Message Text Formatting System, technical standard about the construction of the messages.
[18] C2SIM: Standard for Command and Control Systems - Simulation Systems Interoperation, SISO-STD-019-2020
[19] LOGFAS - NATO Logistics Functional Area Services (Logistics Systems)
[20] TOPFAS - Tools for Operations Planning Functional Area Services, NATO NC3A

Regarding the operation of the simulation system:

- The design of the system should ensure that the independent end-user could create, modify tasks, execute and evaluate exercises.
- The end user should be able to modify and extend the terrain and tactical database.
- The headcount of the fixed group supporting the execution of the exercises should not exceed 30 people.
- In preparation for a particular exercise, learning the role player / operator tasks should not take more than 1 week and should basically be feasible in the garrisons. Refresher training should take a maximum of 3 days.

Regarding the cost-effective operation of CAX systems:

- Due to labour market trends in recent years and declining resources / growing needs, the militaries of most countries operating modern CAX systems have to modernize existing systems. An important element of that is that their existing systems should be operated at well-planned cost and human resource levels, and should even be operated using internal resources.

To achieve this, three levels need to be established and collaborated:

- Manufacturing / software development companies
- Development companies provide continuous updates and background support to address technical issues that arise during an exercise.
- Central operating staff
- Their task is to operate the systems, to train garrison personnel.
- Garrison role player / operator staff
- A group of 2-3 people must be trained for this task.

Of course, not all of the listed requirements can be fully met, in several cases neither the legal situation or the economy makes it possible. However, it can definitely be a good starting point when formulating a set of requirements.

Constructive simulation systems (CAX) in Hungary

During the last decade, the use of simulation tools has become decisive in modern training in all militaries of the world, mainly due to lack of resources. With their help, military exercises and training can be carried out in a risk-free environment, cost-effectively, taking into account environmental aspects as well, in conditions close to reality.

With the appearance of new equipment to be procured within the Zrínyi 2026 force development program, it is necessary to review the operational / tactical requirements of the

simulation capabilities available at the Hungarian Armed Forces. Due to the technical modernization of the Hungarian Armed Forces, new tasks are emerging, but they are also new opportunities for the Hungarian defence industry. Building on existing live, virtual and constructive (CAX) simulation systems, they can get involved in international circulation, while helping interoperability ambitions. Hungary has joined the EU BattleLab[21] and CBRN SaaS[22] PESCO projects and is the leader of the EUROSIM[23] PESCO project.

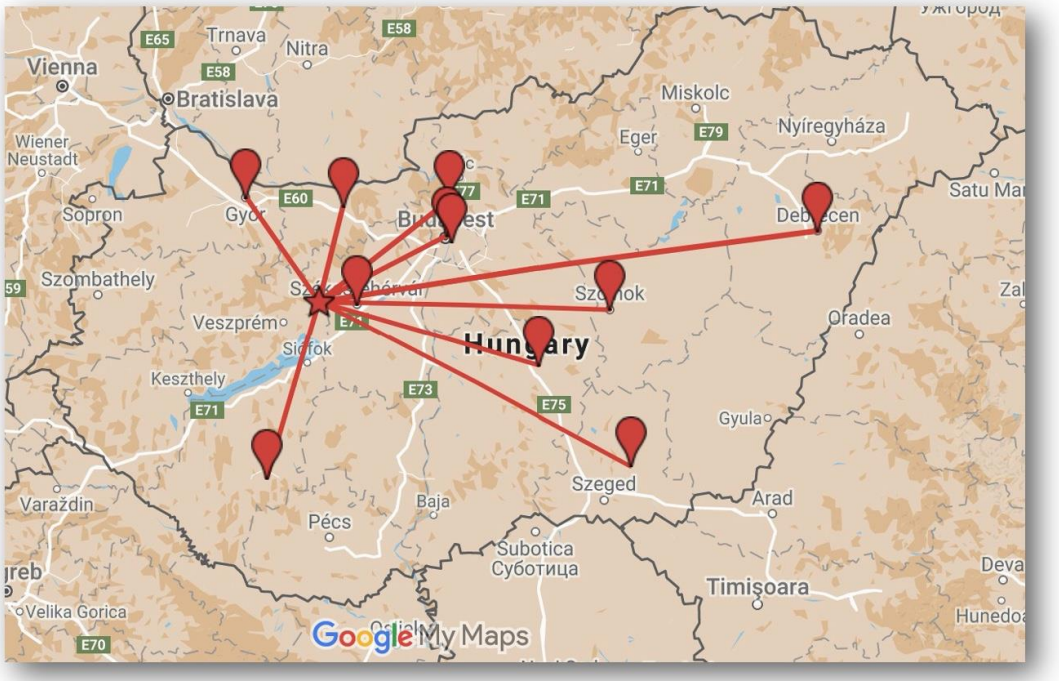

Figure 3. The Hungarian distributed simulation network, integrated MARCUS-KRONOS-ZEUS-MTR environment. (Source: http://www.artifex.hu/hu Accessed 19 February 2021.)

Since its introduction in 2000, the MARCUS simulation has been continuously adapted to the changed geopolitical situation and doctrines, the application areas have been expanded and further developed in the latest versions. Currently, MARCUS v 14 is the latest available version that can be connected to other simulation systems (e.g., KRONOS) and other nations'

[21] The EU-Battle Lab (EDIDP) project aims to develop a distributive simulation capability that is an open, modular, scalable IT system and, in addition, capable of connecting to simulation systems already in use in NATO. Areas of application: education and training, decision support, research. HM EI Zrt. Participates in the project from the Hungarian side. Upon successful implementation, a prototype, "demo" kit and its documentation will be completed.

[22] GAMMA Zrt and BHE Bonn Kft are participating in the PESCO-launched EDA project on behalf of Hungary.

[23] The aim of the Integrated European Joint Forces Multi-Purpose Training and Simulation Center (EUROSIM) project is to develop a system for the simulation of multinational joint operations in the European Union for the joint training and exercise of the forces of the member states. The main element of the simulation system will be a data link that meets information security requirements, ensuring that the countries participating in the project connect their existing simulation centers in real time, creating the possibility of an international, joint force training. The project is to be developed by 2025 under the leadership of Hungary, within the framework of international industrial cooperation. Artifex Simulation and Training Systems Ltd, HM EI Zrt., CAE Hungary and 4iG Nyrt. participate in the project from the Hungarian side.

simulation systems (e.g., JCATS) via a standard HLA[24] Evolved interface. The MARCUS-C2[25] connection is also possible.

The MARCUS simulation is a joint integrated model that is suitable for modelling not only military operations, but also disaster management, terrorism, peacekeeping and other areas.

Paradigm change in the field of operation

In the past year, the development of the next generation of MARCUS software (MARCUS v20) related to CAX systems has started which will not only have new capabilities, but also contains the possibility of even more cost-effective operation.

During scenario executions, the simulation systems are handled by professional military role players, not civilian operators. The professional staff providing the background for the operation is limited to planners, OPFOR[26], DISTAFF[27] and AAR operators and technicians. With the new operating rules, users can now use standard procedures in NATO to conduct CAX exercises. Officers learn to operate the simulation system, come into contact with the technology, and learn a skill they can also utilize during exercises abroad.

In 2016, during the Brave Warrior exercise, the MARCUS v12 simulation was installed in Slovenia and Croatia. At the Croatian site, after a few days of training, the Croatian officers were already handling the MARCUS simulation.

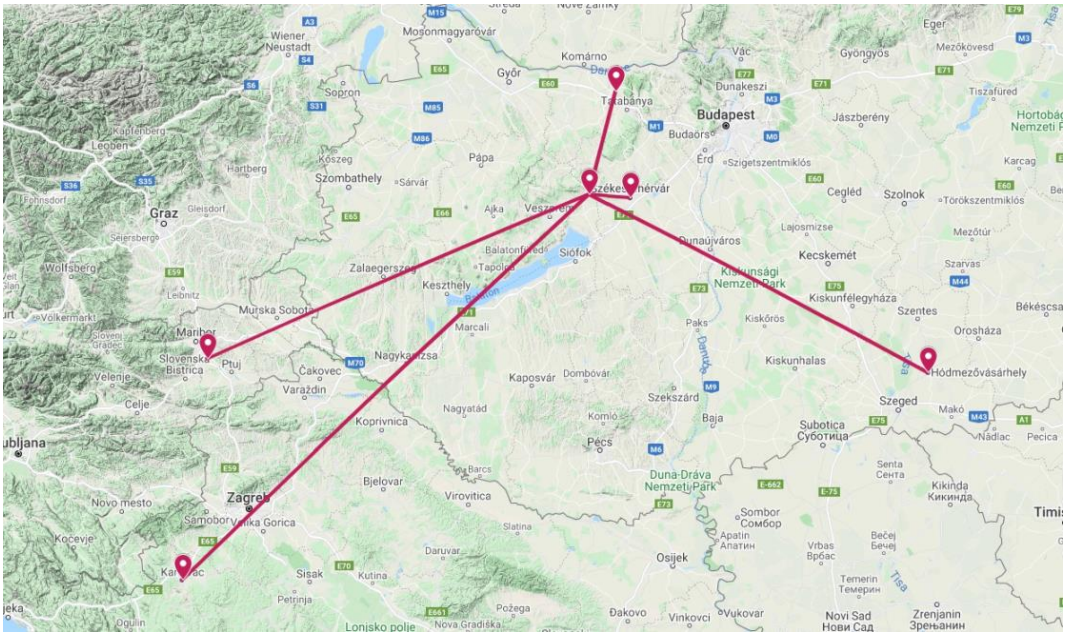

Figure 4. Brave Warrior 2016 Deployment site of Marcus simulation. (Source: https://caxsupport.wordpress.com/2016/10/04/brave-warrior-2016/ Accessed 19 February 2021.)

[24] HLA Evolved: IEEE 1516-2010 - IEEE Standard for Modelling and Simulation (M&S) High Level Architecture (HLA)-- Framework and Rules, NATO STANAG 5603 / IEEE
[25] C2: Command and Control
[26] OPFOR - Opposition Force
[27] DISTAFF - Directing Staff

MARCUS simulation can be customized for users, the user interface can be simplified according to the application area (e. g. artillery, air force, tank, etc.), which significantly helps both training and execution.

Tasks related to the transformation of CAX operating technology and their expected results

Due to the reduction in the number of civilian personnel and the redeployment of tasks, the existing operation and practice implementation technology needs to be reworked to adapt to the new division of tasks.

The topics for the training of professional military personnel participating as trainees in practice and the terms of the training (number of personnel, required practice and knowledge, etc.) should be developed. During the planning of exercises, the preparation of military role players should also be planned.

In order for the professional staff to be able to prepare for the use of the MARCUS simulator in a short time, it is advisable to implement the following improvements:

- extension of intuitive functions
- further simplification of the user interface
- built-in education support features
- expansion of automations

Significant headcount savings:

The transformations will drastically reduce the number of civilian personnel currently providing the operation of simulation systems. From 4 months after implementation 35, and from month 6, 20 people will be able to prepare the system for the exercises and support the professional staff during the exercises. Experience has shown that further redundancies may be envisaged.

Exercise name	BLUEFOR	OPFOR	3rdparticip ant	Mars	Mars	Mars	total	gain
Bocskaifokos 2010	23/5	10/9					33/13	-20
Decon 2011	24/5	6/5					30/10	-20
Acélpenge 2012	12/3	8/6	4/2	5/2			29/13	-16
Pegazus	6/1	2/2		5/2			13/5	-8
Decon2012		12/9		9/2	7/2	6/2	34/15	-19
Jeges Tisza	14/4						14/4	-10
Bocskaifokos 2012		11/8		9/2	7/2	6/2	33/14	-19
Logistical exercise 2009	28/5	2/2	1/1				31/8	-23
Sötétfelhő 2012	9/3	7/6					16/9	-7
Black Horse	18/4	1/1	1/1				20/6	-14

Figure 5. Envisaged headcount of operators/pucksters, based on previous exercises (current number/expected numbers in the new system). (Source: made by the author.)

Overall, with the new version, the system can be operated with a central staff of about 32.

Ongoing developments related to the MARCUS system

MARCUS short-term development tasks (2020-2022):

International cooperation with other organizations and systems (SIM[28]-SIM and SIM-C2 connection) will continue along the results achieved so far in the field of Interoperability.

The development continues to focus on further simplifying the handling and operation of the simulation. Both in Hungary and abroad, it is important to be able to carry out as many exercises as possible with as few operators as possible. In the interest of cost-effective operation, further improvements can be implemented, which will further increase the possibility of economical operation in a very short time. The new MARCUS version has already been designed in accordance with the above operating principles.

NATO supports and even expects national systems to work together in a number of areas. Within this, the solution of simulation-simulation and simulation-management system relationships is essential, as the implementation of simulation exercises only creates a realistic environment when these IT systems are connected.

The aim is to connect the already interconnected nationally developed simulation systems (MARCUS, MARS, KRONOS) with other simulations/simulators used in Hungary (e.g. FABV

[28] SIM – Simulation

Trainer[29], Electronic Warfare Simulator[30]) and in NATO (e.g. JCATS[31], WARSIM[32]) developed for military or disaster protection purposes (e.g. Building EXODUS[33]). To this end, the application of the NETN FOM[34] developed by the HLA Working Group and the search for additional partners for further interoperability tests and the development of HLA capability will be an ongoing task.

Figure 6. FABV Trainer simulator room in HDF 93rd Petőfi Sándor CBRN battalion. (Source: http://www.gammatech.hu Accessed 19 February 2021.)

Based on the results obtained so far in CWIX[35] exercises (CWIX capability tests with other NATO nations' C2 systems), the technology is available to perform data exchange between MARCUS simulation and C2 systems and to stimulate C2 / C4I[36] systems. After the international data exchange, the connection of the Hungarian-developed C2 system and the simulation must also be implemented.

To support the execution of the simulation exercises, NCIA[37] launched the EXIS[38] project, which was renamed NISE[39]. The work is coordinated by the JFTC[40].

[29] The training system developed for the operator of the VS BTR 80 chemical reconnaissance vehicles of the Hungarian Defense Forces. It is developed by GAMMA Műszaki Zrt, Hungary's leading defense company, currently with the widest Hungarian defense product portfolio.

[30]As part of the Electronic Warfare development launched within the framework of the Defense and Armed Forces Development Program, the methods of radio electronic detection and interference can be mastered on modern equipment in the laboratory established at the Department of Electronic Warfare of the NKE HHK [16].

[31] JCATS: Joint Conflict and Tactical Simulation, Lawrence Livermore National Laboratory

[32] WARSIM: Warfighter's Simulation, Lockheed Martin

[33] The evacuation simulation program (EXODUS) developed by the Fire Safety Engineering Group (The Faculty of Architecture, Computing & Humanities UNIVERSITY of GREENWICH) can be used for evacuation simulation of buildings, dynamic pedestrian behaviour and traffic analysis. https://fseg.gre.ac.uk/fire/EXODUS_animations.asp (Accessed 19 February 2021).

[34] NETN FOM - NATO Education and Training Network Federate Object Model, NATO MSG-068 Working Group

[35] CWIX - Coalition Warrior Interoperability eXploration, eXperimentation, eXamination, eXercise[12][13]

[36] C2/C4I: Command and Control / Command, Control, Communications, Computers, Intelligence

[37] NCIA: NATO Communications and Information Agency

[38] EXIS: NATO Exercise Information System

[39] NISE: NATO Information Service for Exercises, NCIA

[40] JFTC - Joint Forces Training Centre, Bydgoszcz, Poland

The Hungarian company developing MARCUS was also invited to work on this project.

The efficiency of the training service can be increased by practicing not only on fixed-installation workstations, but also at mobile simulator points deployed in addition to specific military exercises. One of the most effective solutions for this purpose is the Defence Mobile Simulator Centre (VMSzK). With the help of the Industrial Strategy Support Programme of the Irinyi Plan, funded by the Irinyi Plan Industrial Strategy Grants appropriation, GAMMA Zrt has developed a multi-purpose container family with an expandable floor area. The new version of MARCUS is designed to be optimally operated in a mobile environment on a scalable scale. The demonstration tool is implemented in one of the elements of this multi-purpose container family with expandable floor space.

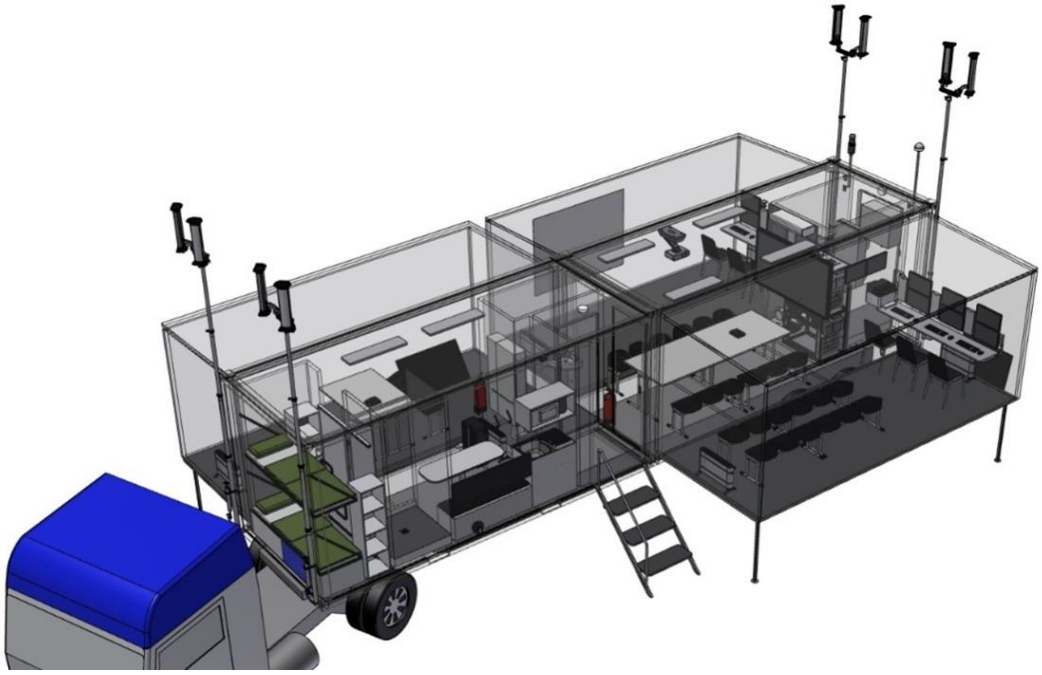

Figure 7. Visual design of a multi-purpose, expandable container system. (Source: http://www.gammatech.hu Accessed 19 February 2021.)

For simulation training, mobile systems are required in the following areas:

- constructive simulation: mainly in the fields of non-military training, such as law enforcement, disaster management, terrorism and critical infrastructure protection. Operation can obviously be done with military assistance;
- virtual simulation: support for voluntary reserve training at national level. Tactical training of small subunits, even at the individual warrior level;
- shooting training: voluntary reserve training, mobile shooting range.

Due to its nature, the utilization of the tool can be maximized, the cost of each exercise can be significantly reduced, and the rate of return is very high. Additional training systems can be implemented on the basis of the container simulation system to be developed.

MARCUS long-term development tasks (2022-2026):

The constant threat of migration, the civil war situations around the world, mission tasks, relentless terrorism, cybercrime and the epidemic that appears from time to time also justify the further development of training for these tasks. In order to prepare more effectively, existing simulation models need to be further expanded (e.g. operation of camps, assembly and management of teams, border control, special counter-terrorism equipment, explosives, explosion effects on humans and the environment, mass screening, blasting, chemical attack in metros or confined spaces).

In the current geopolitical situation, virtually all NATO operations take place in a civilian environment, which must also be reflected in training. MARCUS simulation is currently suitable for displaying / inserting limited civilian actions in the scenarios, but an intensive civilian environment (movement of civilian aircraft, ships, vehicles and people) can only be realized if artificial intelligence automatically generates it in the virtual space without operator intervention or with little intervention.

During commander and staff training, the supportive simulation system should be able to represent cyber-attacks as well, manage their consequences, and thus force the training audience to recognize them and make decisions.

New opportunities in the field of simulation center, national simulation capability as a result of these developments

In addition to the recommendation of the national simulation center and training capability, it is possible to set up a mobile simulation training group. The group would have the aforementioned 3x20-foot container, equipped with the infrastructure needed to carry out the exercise (servers, OPFOR and DISTAFF workstations, network elements). At the installation site, the role players' workstations are provided by the party using the service and are connected to the mobile system. The training team also performs the pretraining of the role players and the training audience.

A visible strategic direction is for nations to use their own tools to create a complex training tool (LVC SIM[41]) that can be considered an integrated system. The USA is the leader in this area, but several other NATO members have already reported their successes. The LVC design is not only an infrastructure, thus the associated training system needs to be developed. The creation of this kind of system allows multi-level simulation exercises to be carried out.

Of the systems currently in use, MARCUS, KRONOS, and TRACKS[42] (prototype) are currently able to work together in a common simulation exercise.

[41] LVC SIM - Live-Virtual-Constructive Simulation

[42]TRACKS peacekeeping reconnaissance simulator prototype suitable for patrol training, was completed as part of the ITM tender, developed specifically to prepare for UN missions in Africa. The system is very similar to the FABV training simulator

The example of other nations shows that simultaneously with the interconnection of simulation systems, the interconnection of command-and-control systems with the simulations also takes place.

Communication interfaces:

- Among simulators: HLA Evolved, DIS[43]
- Towards C2 / C4I systems: ADatP-3, MIP[44], C-BML[45]

New opportunities created as a result of the developments in the field of international relations and cooperation

Recommendation of the Simulation Center for international usage:

Although all NATO members have simulation training capabilities, only Hungary, Germany and France have a CAX training background that is nationally developed. Other nations use predominantly USA systems, which pose serious technical, material, and administrative problems for both operation and customization and further development.

Moreover, according to an official NATO announcement the very widespread JCATS and JTLS[46] systems have no future, and will need to be replaced within a few years.

For 15 years, NATO has held the CWIX exercise once a year, which tests the interoperability of various command and control systems, simulation and other IT systems and capabilities used by NATO nations, see http://www.act.nato.int/cwix. The aim of this work is to effectively develop cooperation between NATO systems.

The tests take place in subgroups (Focus Area) that participants can join. During the preparation, it is decided who wants to test what and participants find partners.

Hungary currently works in 4 Focus Areas:

- FMN47 (general networking, infrastructure tests)
- Cyber Defence
- Modelling and Simulation (ARTIFEX)
- Land (HM EI, C2)

developed by GAMMA. 1 workstation dedicated to driver and vehicle / patrol commander. With the help of 3D and digital maps, several patrols can practice their mission in a network, in addition, a "command" workplace has been created. Communication takes place on a simulated radio network.

[43] DIS - Distributed Interactive Simulation (*DIS*) is an IEEE standard (IEEE 1278-1993, DIS 7: IEEE 1278.1-2012)

[44] MIP - Multilateral Interoperability Programme

[45] C-BML - SISO-STD-011, "Standard for Coalition Battle Management Language Phase 1"

[46] JTLS - Joint Theater Level Simulation, Rolands& Associates Corp.

[47] FMN- Federal Mission Network

In the simulation working group, the HDF offered the MARCUS capability. The developers have performed a number of interoperability tests for both simulations and C2 / C4 control systems.

Summary

In the field of military simulations, Hungary also has excellent products in international comparison. The world-class MARCUS constructive simulation operates in the Simulation Center of the Hungarian Defense Forces (HDF) in Várpalota and in several garrisons, which ensures the full service of the staff training. The MARCUS system is suitable not only for military but also for civilian use in the training of disaster management, critical infrastructure protection, terrorism and the fight against drug trafficking. Unlike competing systems, MARCUS simulation is extremely flexible, can be quickly adapted to individual needs, and can even be easily expanded by the user.

Figure 8: Cutting edge simulation, training and test environment, (Source: picture made by the author, 25 June 2021.)

Last year, the development of the next generation of MARCUS software was also launched, which will not only have new capabilities based on user needs, but also comes with the possibility of more cost-effective operation. An important element of the improvements is that the system can be operated at well-planned cost and human resources levels, so that it can be operated with a lower number of operators (even the employer's own operation) who perform the task on a case-by-case basis.

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Conflict of Interest

The author hereby declares that no competing financial interest exists for this manuscript.

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