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HUNGARIAN FIELD ARTILLERY FIRE CONTROL SYSTEMS – PAST AND FUTURE

A MAGYAR TÁBORI TÜZÉRSÉG TŰZVEZETÉSI RENDSZEREI – MÚLT ÉS JELEN

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Abstract

The Hungarian Defense Forces has launched Zrínyi 2026 Defense and Military Development Program in January 2017, which is the largest defense and military development program of the last twenty-six years. The modernization of the Hungarian Army's artillery will sooner or later occur - whether within or outside the Zrínyi 2026 program. This publication reviews the Arpad Hungarian Artillery Fire Control System (AFCS) which was developed in the 1980's and 90's. In addition, the author attempts to conduct an extensive search for sources that may define further research directions. We must be aware what a state of the art AFCS is like. The aim of this publication is to make a contribution for future development of Hungarian AFCS by forming the way of thinking of experts to be involved in relevant efforts. This knowledge is inevitable whether or not Hungary will purchase or develop itself her AFCS.

Keywords: *Zrínyi 2026, artillery, automated fire control system, Arpad, technology development*

Absztrakt

A Magyar Honvédség 2017 januárjától indítja el Zrínyi 2026 Honvédelmi és Haderőfejlesztési Programot [1] ami az elmúlt huszonhat év legnagyobb honvédelmi és haderő-fejlesztési programja. A Magyar Honvédség tüzérségének korszerűsítésére előbb-utóbb minden bizonnyal sor fog kerülni – akár a Zrínyi 2026 program keretében, akár azon kívül. Jelen publikáció áttekinti a magyar tűzvezető rendszerrel kapcsolatos előzményeket – konkrétan az 1980-as és 90-es években kifejlesztett Árpád tűzvezető rendszert. Emellett a szerző kísérletet tesz egy olyan forráskutatásra, amelyek felvázolnak további irányokat, és amelyek tanulmányozásával világossá válhat az érintett szakemberek számára, hogy egy korszerű tűzvezető rendszer napjainkban hogyan épül föl. Ezek az ismeretek feltétlenül szükségek, függetlenül attól, hogy Magyarország beszerzi vagy kifejleszt az tüzérség tűzvezető rendszerét.

Kulcsszavak: *Zrínyi 2026, tüzérség, automatizált tűzvezető rendszer, Árpád, haditechnikai fejlesztés*

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INTRODUCTION

First of all we must to say clearly that Artillery Fire Control System (AFCS) is not a general remedy for artillery modernization – but it is a very important part among the many aspects of effectiveness of an artillery unit. This approach is seen in a publication of Chief of the Field Artillery and Commandant of the US Army Field Artillery School, Fort Sill, Oklahoma [1]. Beyond AFCS target acquisition radars, targeting devices, laser designators, precision targeting devices, sensors etc. are essential components as well.

REVIEW OF ARPAD AUTOMATED FIRE CONTROL SYSTEM

In the second half of the 1970s, the Hungarian People's Army Rocket and Artillery Command realized that the Hungarian Army's artillery did not meet neither the modern requirements nor the requirements of the Warsaw Pact Technical Command. For this reason the Command has initiated the development of an advanced fire control system that provides an efficient fire management system.

The system prototype defined at the start of the development was completed in 1986 after the required tests and the successful completion of the trial. The first variant of the Arpad system produced in 1987 was built into the combat vehicles (command posts) of the Soviet made 1V12 Mashina system in the following composition: 8 sets of microcomputers in the command post's vehicles; 18 sets of gun display indicator for the Soviet made 2S1 self-propelled guns; 4 sets of reconnaissance data transmission equipment for forward observers; printer and meteorological equipment in the vehicle of fire control command post of the artillery battalion.

The main tactical-, technical parameters of the fire control system were as follows: full automated processes from target designation to the start of gunfire; the reaction time of the system of the artillery battalion was less than 1 minute; the calculation error is less than 1 mil, the calculation time was less than 25% of the flight time of the projectile; 1200 bit/sec data transmission rate; effective error correction method for data transmission; defence against jamming; operating temperature range of microcomputers (-30 ... + 65) C.

I offer to the reader a detailed and comprehensive publication on the Arpad system, containing a number of photographs, diagrams and comparative analysis[1] from the AARMS journal [2], and a publication from a different approach by an excellent artillery officer[3].

I do not intend to summarize the above mentioned AARMS publication, better to quote some words from the Abstract: „In Part I the reader will become acquainted with the formation and the present features of the Arpad fire control system including the phases of its development and an outlook of the possible future improvements. In Part II Arpad system is compared with other systems using a very new approach based on mathematical methods of theory of complex systems."

The results of the comparative analysis made in Part 2 of the AARMS publication are shown in the two figures below:

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[1] using MCDM (MultiCriteria Decision Making methodology)

[2] J. Gyarmati , Dr. G. Kende, T. Rózsás, Dr. K. Turcsányi: The Hungarian field artillery fire control system ARPAD and its comparison with other systems. Academic and Applied Research in Military Science (AARMS) 1:(1) pp. 9-38. (2002) http://uni-nke.hu/downloads/aarms/docs/Volume1/Issue1/pdf/01gyar.pdf (retrieved: 14.07.2017.)

[3] Bóka Sándor: Past, Present and Planned Future of the Fire Control in the Hungarian Field Artillery. Haditechnika C+D Special Issue, 1997,74–77. p.

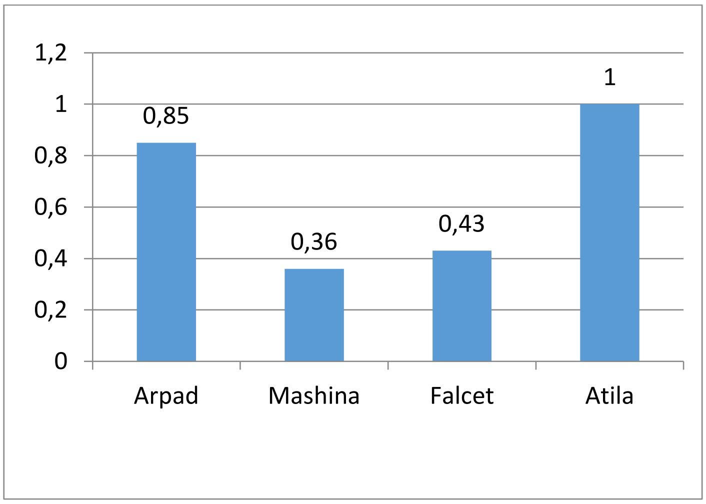

Figure1 Comparison of Arpad AFCS with Soviet Mashina and Falcet system and with French Atila system in Warsaw Pact era[4]

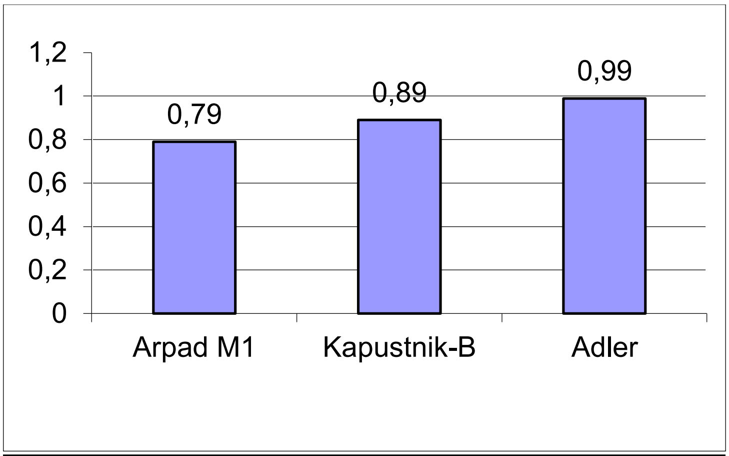

Figure 2. Comparison of Arpad AFCS with Soviet Kapustmik-B and German Adler system in the period of NATO accession[5]

Foreign references to Arpad system

Arpad system was well known abroad, not only in Warsaw Pact countries but in others as well. I can offer two references – one in International Defence Review (IDR)[6], one in Soldat und Technik[7]. We copied the IDR publication and a quotation from the Soldat und Technik.

4 http://uni-nke.hu/downloads/aarms/docs/Volume1/Issue1/pdf/01gyar.pdf p.32. (retrieved: 14.07.2017.)
5 http://uni-nke.hu/downloads/aarms/docs/Volume1/Issue1/pdf/01gyar.pdf p.34. (retrieved: 14.07.2017.)
6 Hungarians enter artillery fire-control market. International Defense Review, 1991. 4. sz. 367 p.
7 Gueckler, A.: Ungarisches Artillerie-Feuerleitsystem „Árpád”. Soldat und Technik, 1993. 2. 118-119. p.

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Programs and equipment

Hungarians enter artillery fire-control market

As a centre for excellence in electronics within the former Warsaw Pact, Hungarian industry has developed in conjunction with the Soviet and Hungarian armies a microprocessor-based artillery fire-control computing system known as ARPAD. It is now on offer by the state-owned Idex company of Budapest as an upgrade to what it describes as Soviet "Mashina"-type artillery command complexes. (An Idex promotional film depicts a 1V12-series ACRV command vehicle.) However, elements of ARPAD could also be adapted to suit non-Soviet artillery practices and sales negotiations are said to have reached a late stage with an unnamed African country.

As currently developed, ARPAD is configured to serve as a Soviet-style battalion-level technical fire control system, several Hungarian army battalions having already been re-equipped. Ultimately it is envisaged that the system could be expanded to handle computing tasks within an artillery "group", according to an Idex spokesman. The basic battalion set comprises standard 15kg containerised vehicle-borne computer units for the battalion and chief-of-staff command posts, the three battery command posts, and three battery fire direction posts. The computers at the battalion and battery command posts (which double as observation posts) are also equipped with demountable 5kg remote-control consoles which can be set up 200m from the parent vehicle. There are in addition 18–27 display units for use at the gun end.

Each computer unit, based on Motorola 80C85 16-bit microprocessors and AM9511 arithmetic processors, can generate individual firing data for up to 18 guns. Thus there is a high level of redundancy within the battalion if one or more of the eight computing nodes should be knocked out. Ballistic data is currently available for Soviet 2S1 122mm and 2S3 152mm self-propelled howitzers, and computing speed is typically 25 per cent of the time of flight. Communication within the battalion is by line or via standard Soviet-pattern VHF vehicle radios (frequency range 20–60MHz), with data transmission speeds of 600/1,200 baud respectively. Either 12V or 24V DC power supplies may be used.

According to Idex, ARPAD is fully functional over the −40°C to +70°C temperature range and has a mean time between failures of 15,000h. Both LCD and gas-plasma alphanumeric display formats are offered, but it is not clear how effective the former would be in extreme cold. For customers requiring them, Idex offers a laser rangefinder (believed to be Yugoslavian), and is understood to be developing a digital message device for forward observers.

The Idex ARPAD computer unit features a plasma display and can generate data for up to 18 guns. On-line surface meteorological data from a tripod-mounted automatic meteorological set at the battalion chief-of-staff's location can be factored into the calculations in real time. Visible left is the associated gun data display unit.

Underwater telephone developed in UK

Graseby Dynamics G732 MkII underwater telephone is compatible with all other underwater telephones operating at NATO frequencies. A choice of transducer installations is available to meet customer requirements.

Graseby Dynamics in the United Kingdom has developed an improved version of its G732 underwater telephone, the G732 MkII, for use in surface ships and submarines (a portable variant of the MkII is also available for shore-based and helicopter operation).

Based on proven technology, the MkII incorporates many design refinements over existing equipment and provides facilities for voice (speech), morse, digital and coded messages, as well as an emergency pinger mode of operation. The receiver/transmitter electronics are housed in a ruggedised bulkhead-mounted unit which connects to one or more transducers to produce directional transmissions. The G732 MkII operates from the ship or submarine's 115V AC supply. A battery-powered unit can be supplied to maintain communication in the event of a power failure.

Graseby Dynamics Ltd is now able to offer extended range transducers for use with the G732 MkII. In addition to the original hull-mounted transducers a range of lightweight omni-directional transducers are available. These are intended for dunking either from a helicopter or a small boat. The G732 MkII operates in the 8.4kHz to 11.3kHz TX/RX frequency band using upper SSB (NATO compatible) mode of transmission.

Trigat flies

The tri-nationally funded, long-range Trigat anti-tank missile has successfully completed its first test flight. The Euromissile Dynamics Group (EMDG), consisting of Aerospatiale, Messerschmidt-Boelkow-Blohm and British Aerospace, said that the first flight had to prove the missile's ability to clear the launcher and fly in a ballistic flight path for the full duration of the rocket motor burn. This was achieved, and the results have been accepted by the Bureau Trilatéral de Programme (BTP) which represents the interests of the three participating nations. In another announcement from BTP, it has been confirmed that the next program payment tranche is to be made, which is regarded by EMDG as confirmation of the success of the Trigat program to date. The payment covers development of the complete system including the missile, tracker and fire control unit.

Correction: In the March issue of *IDR* a photograph of the Pakistani Yasoob truck carried a caption referring to the AWD Multi-Drive system deployed in the Gulf. This had been transposed with the correct caption which appears on Page 264 under the title "ZF components equip Pakistani trucks".

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Figure 3. The International Defence Review on ARPAD system[8]

Quotation from the Soldat und Technik[9]:

„Mit ihrem Feuerleit- und Informationssystem Árpád hat die ungarische Rüstungsindustrie die offensichtliche Achillesferse des Artillerieführungkomplexes 1V12[10] beseitigt und es damit ohne grossen Aufwand in die Neuzeit katapultiert."

English translation (author's translation): "With its fire control and information system Arpad, the Hungarian armaments industry has eliminated the obvious Achilles heel of the artillery command complex 1V12 and thus catapulted it into the modern era without much effort."

I do not intend to formulate the main lesson learned from the development process. Instead let me quote the evergreen and general conclusion of the Hungarian scientist Dr. Theodore von Kármán (1881-1963)[11]:

„… scientific results cannot be used efficiently by soldiers who have no understanding of them, and scientist cannot produce results without an understanding of the operations."[12]

[8] Hungarians enter artillery fire-control market. International Defense Review, 1991. 4. sz. 367 p.

[9] Gueckler, A.: Ungarisches Artillerie-Feuerleitsystem „Árpád". Soldat und Technik, 1993. 2. 118-119. p.

[10] Gueckler, A.: Das sowjetische Artillerieführungssystem 1V12. Soldat und Technik, 1991. 2. 134–136. p.

[11] „ a well-known aeronautical scientist…he conceived the idea of an Advisory Group for Aeronautical Research and Development (AGARD) under the umbrella of NATO" AGARD The History 1952-1997. Editor: Jan Van der Bliek. 1999. The NATO Research and Technology Organization (blurb).

Possible Research Sources

When time comes for building the Hungarian AFCS we must have a look around to create a clear picture: What is a modern AFCS like? To answer this question it is advisable to make a comprehensive research using different methods: paper-based and online publications, internet search, ProQuest Military database, NATO STANAG-s[13], NATO homepages, NATO working groups. It might be also useful to study NATO forecast[14] which of course is not artillery specific but focused on land forces technology.

NATO Standardization Agreements (STANAGs)

Using the „OLIB Web View" website of National Public Service University library[15] and choosing keywords „artillery and stanag" we find 9 NATO artillery STANAGs. From viewpoint of this publication 4 of them are relevant:

- Artillery procedures - AArtyP-1(A): STANAG 2934 / NATO. - 2. ed.
- Adoption of standard artillery computer meteorological message: STANAG 4082 / NATO. - 2. ed.
- Dynamic firing techniques to determine ballistic data for cannon artillery firing tables and associated fire control equipment: STANAG 4144 / NATO. - 1. ed.
- Field artillery and fire support data interoperability: STANAG 2245 / NATO. - 1. ed.

Printed and online publications

One of the most comprehensive sources, the Jane's Land Warfare Platforms Artillery and Air Defence 2012-2013 handbook [2] deals mainly with weapons, guns, howitzers, mortars etc. and only in smaller extent with AFCS. But this short description deserves some attention. Since later on we will review NATO AFCS let's have a look to east. Russia is marketing a new AFCS that can be integrated into self-propelled artillery systems such as the full-tracked 152 mm 2S19, 152 mm 2S3 and 2S1 as well as multiple rocket launchers such as 122 mm BM-21 multiple rocket launcher. The heart of the AFCS is a central computer that receives/sends information from a variety of sources including a gunners indicator display, commander's automated combat station, loaders, mechanical velocity sensor and a self-orientating system of gyro course and roll indicator.[16]

Publication "Summoning the Fire" provide a good overview of some NATO and non-NATO countries (USA, Britain, France, Germany, Sweden, Austria, South Africa) AFCSs [3]. I propose a quotation from this article which gives a clear and simple picture of AFCS architecture and processes: „The general configuration of the SaabTech Systems Sker is similar to that of most modern fire control systems. Data sent by radio from forward observers is processed in a fire control computer, and details of the resulting fire missions are passed to individual Gun Display Units.[17] Since this general configuration for almost all AFCS (including Arpad) I do not review the different systems mentioned in this publication it might be useful for further research.

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[12] AGARD The History 1952-1997. Editor: Jan Van der Bliek. 1999. The NATO Research and Technology Organization. p. 1-1.

[13] STANAG stands for Standardization Agreement

[14] Land Operations in the Year 2020 (LO 2020) NATO Research and Technology Organization RTO-TR-8 AC/323 (SAS)TP/5) 251 p.

[15] https://opac.uni-nke.hu/webview?infile=searchform.glu&style=kws (retrieved: 14.07.2017.)

[16] Christopher F. Foss, James C. O'Hallorey: IHS Jane's Land Warfare Platforms. Artillery and Air Defence 2012-2013. 826 p.

[17] ibid. 14.p.

There are many publications on US AFCS - Advanced Field Artillery Tactical Data System (AFATDS). One of them, a software-oriented publication [4] deserves special attention from point of view of further Hungarian efforts. This publication on AFATDS emphasizes the importance of this system not only for its role in Operation Iraqi Freedom (OIF) but because of being an integral part of the Army and Marine Corps command and control (C2) network- centric architecture. During planning the Hungarian AFCS it will be useful to know the main features of AFATDS software[18] which provides functionality in four major areas: situational awareness, battle planning, battle management (execution), and fires/effects processing. It provides target analysis and weapon selection logic that ensures that the right munitions are placed on the right target at the right time. In Operation Iraqi Freedom (OIF), the AFATDS prevented friendly fire accidents, provided additional protection to friendly forces, and created significant savings in weapon systems and ammunition costs.[19] Having scare resources savings should be a significant goal in our efforts.

I found an interesting thesis written for MSC degree in Information Technology Management in USA.at Monterey, California, Naval Postgraduate School [5]. The author - a Major - during Operation Iraqi Freedom experienced that via the traditional fire support communication network (i.e., both voice and data communication on Very High Frequency (VHF) radios, voice communications on both Ultra High Frequency (UHF) and High Frequency (HF)). call for fires went unanswered by the artillery battery. The situation dictated that every available means be used to communicate enemy targets to the artillery battery in defence of the Command Post (CP). The author, as a trained Forward Observer, called the artillery battery using the Kuwaiti cellular phone issued for inter-camp coordination prior to the start of OIF. The artillery battery answered the cellular phone call and shifted to support the defence of the CP. As a result, the Iraqi paramilitary force concentrations were repelled and the CP remained secured. This combat experience posed a question: "Why can the most technologically advanced country on earth not develop a communications device that simplifies the users' actions by consolidating the capabilities of the several required communications devices into one 'smart' device." In combat, the warfighter should ideally carry one smart device that can communicate on all required networks and formats, both voice and data, to achieve maximum effectiveness while minimizing equipment[20].

Let me add that in the 1980's we made tests with Hungarian hand-held computing device PTK-1096. This unit was able to execute necessary artillery calculations including firing elements (elevation, azimuth, etc.) but naturally was not able to communicate. Today's smartphones are much more sophisticated and deserve a closer look at least as an auxiliary mean for AFCS functions.

Conclusions and some other research options

All in all: advanced AFCS are characterized with sophisticated information technology and communications devices, universal architecture, sensors and other means. Studying this systems we can draw our own conclusions on principles and practical solutions to draft an optimal system for our artillery.

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[18] Palmer, Laura (2004): The Advanced Field Artillery Tactical Data System Proves Successful in Battle. In Crosstalk 17 (7), p. 6. http://www.crosstalkonline.org/storage/issue-archives/2004/200407/200407-Palmer-4.pdf, (retrieved: 14.07.2017.)

[19] ibid. p.7.

[20] Oregon, Rogelio S. (2011): SMART Fires: A COTS Approach to Tactical Fire Support Using a Smartphone. Thesis. Naval Postgraduate School, Monterey, California. 24. p. http://www.dtic.mil/get-tr-doc/pdf?AD=ADA551955

The possibilities of the development of Hungarian developed of AFCS are also worth examining in the frames of the V4 Visegrad Group Defence Co-operation.[21] V4 defence cooperation has moved on over the last year, the already mentioned areas were perceived as a base for the Action Plan of the Visegrad Group Defence Cooperation and hence worked out into 8 subareas where No. 4 is „Joint Procurement and Defence Industry".

Of course, it is worth looking at the results of some NATO organizations and working groups (eg. CNAD[22], NIAG[23], STO[24]) in the AFCS areas.

SUMMARY

Building an artillery fire control system (at battalion level e.g.) is a complex task because it contains several different components which differ from each other by their task and character. At the moment the Hungarian defence industry[25] is not able to deliver or develop all the necessary elements so it is very probable that modernization of Hungarian artillery will be a combination of research and development activities and processes combined with acquisitions from abroad. Building fire control computers is not a problem anymore thanks to information technology achievements. In this publication I have presented the battalion level Arpad artillery system with the help of a previous publication of mine and my research fellows which shows that AFCS development has serious Hungarian traditions. Now I have outlined possible further research directions. Overall, this article is a step in order to prepare ourselves for the future development of a Hungarian AFCS.

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[21] http://www.visegradgroup.eu/about/cooperation/visegrad-group-defence
[22] Conference of National Armaments Directors
[23] NATO Industrial Advisory Group
[24] Science and Technology Organization

[25] Defense Industry Association of Hungary http://www.vedelmiipar.hu/?module=showpage&site=welcome&group=&menupath=&product=&lang=eng

[4] RICHARDSON, D. (2003): *Summoning the fire*, In Armada International 27 (1), pp. 10-18.

[5] [4] PALMER, L. (2004): The Advanced Field Artillery Tactical Data System Proves Successful in Battle, In Crosstalk 17 (7), pp. 6–7. http://www.crosstalkonline.org/storage/issue-archives/2004/200407/200407-Palmer-4.pdf, (retrieved: 14.07.2017.) OREGON, R. S. (2011): *SMART Fires: A COTS Approach to Tactical Fire Support Using a Smartphone*, Thesis. Naval Postgraduate School, Monterey, California. 149 p. http://www.dtic.mil/get-tr-doc/pdf?AD=ADA551955 (retrieved: 14.07.2