



"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA



"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2013
Brasov, 23-25 May 2013

THE BEGINNING OF RADARS IN HUNGARY

Gabor BERKOVICS - Zoltan KRAJNC

Faculty of Military Science and Officer Training, University of Public Service, Budapest, Hungary

Abstract: *The article reviews of the beginning of radars in Hungary. It gives a general picture of the time between the two World Wars in Hungary, what happened in the country related to this topic. After that the authors analysed the development process of building of radar capabilities in Hungary for WWII including the domestic development and imported systems.*

Keywords: *community, intercultural context, communication*

Introduction

A well- functioning, integrated radar system is too important and specific to be considered simply one of the subordinate elements of the C4ISR system. Undoubtedly, it belongs to the major components of the air defence systems, both in our days and in the times of its early-day appearance. Radars became the most important devices of air reconnaissance during WW2. At those times, however, they constituted a part of different observation and reporting services.

Their importance became obvious from their very first use. They managed to alleviate the drawbacks of the traditional reconnaissance means (eyes, ears, binoculars, listening devices) significantly. They possessed much better qualities, although not without problems, for target detection that did not depend on the season, time of the day and the flight altitude, for the timely access of information for the fighter control, as well as for the air defence missile firing.

The development of radars, their production, and their use in battles wasn't limited only to superpowers, and definitely not only to the British system, highly advertised both in literature and films. Besides German,

American and Russian locator technology, „smaller” states were also able to show results. The Hungarian Royal Army was a good example during WW2.

The Hungarian Army entered WW2 with serious deficiencies. There were two basic reasons for that. On the one hand, the decisions of the Trianon Peace Agreement, signed after the lost Great War, caused about 10-15 years of impediment in the development of the armament, on the other hand, the economic position of the country could not allow the appearance of a modern army. It is an exaggeration to say that the country had to fight its battles on the technical level of the previous wars. But it was obvious that it struggled with serious lack of equipment. These factors soon came into light during military maneuvers. In our article we are going to describe problems arising in the reconnaissance of enemy aircraft and in their military solutions.

The time between the two World Wars in Hungary

The Trianon agreement did not prohibit the formation of the observation and report system for Hungary, only the active military forces

connected with it, as well as the use of air defence artillery and air force. In 1920, the Hungarian commanding staff had already started dealing with the question of air defence, as well as with that of reconnaissance and warning.

The country was divided into seven „Royal military districts” and district commands (1. Budapest, 2. Székesfehérvér, 3. Szombathely, 4. Kaposvár and after the end of the Serbian occupation, Pécs, 5. Szeged, 6. Debrecen, 7. Miskolc) The Air Defence district was established in the same areas in 1922 and later, in 1924, the seven Air defence areas appeared (I-VII)

The main rules of the observation and reporting services were established as follows:

- Gap-free, many-lined battle formation
- „Coverage” of the country’s entire territory
- Combination and deployment of the mobile and immobile sentinels according to their tasks
- Necessary grouping of the forces and equipment to strengthen the effectiveness of air force and air defence
- Conditions and readiness proper for the military, not depending on the time of the year or day
- Timeliness, both in reconnaissance and information, precision (place of service, number of items, flight direction, altitude, activities)
- Organisation of unified, centralised leadership, based on integrated organisation and possibilities
- Based on the district and the setting, from the proper level, information and alarm of the population and the military organisations
- Cooperation between the military units with similar functions, as well as with the civilian defence forces.

The Hungarian radar system in WW2

After Hungary joined the war in 1941 it soon became evident that the observation and reporting services didn’t meet the requirements. On March 31, 1942 a reduced

air defence readiness was ordered in the country, because it was observed that the front line moved from the borders and Soviet air attacks were not expected. It didn’t prove to be the right decision, since there was an air attack against the country on the 4th and later on the 9th of September. In the case of the first one, due to the reduced readiness, the air defence system proved unreliable. It was clear that the expected activities and the defence against them needed a new device: the RADAR.

The Hungarian observation and report system was fully established by the middle of 1943. All air defence centres of the 15th Air Defence Area were operational. In 1944 the exchange of information between all centres and their subunits was automatic. Their staff was comprised of 550 observation and reporting sentries (some of them existed only on „paper” or with deficiency of special and signal equipment.) There was a mobile signal division on readiness with 32 signal sentries, basically for supplement of immobile sentries.

By the beginning of 1940’s the completion of air defence tasks became more and more difficult. Due to this fact the effectiveness of the observation and report system, established earlier, became reduced. There was a need to get the information as precisely and early as possible.

To make the reconnaissance system more effective and to keep its operability was practically impossible without a newer, more modern device. The modern air defence practically „demanded,” the radio wireless location system. To perform the tasks well it was necessary to introduce them to the domestic air defence and its units. The classic problem areas of air defence came into light again, such as the question of early reconnaissance provision, the warning system, the continuous, minimally late information, the activation of forces and equipment, their timely deployment, the optimal division of resources for a successful battle.

By this time radiolocation and radars had a significant past, since Heinrich Hertz proved in 1886 that electromagnetic waves reflect from electrically conducted materials.



"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA



"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2013
Brasov, 23-25 May 2013

The research and experiments conducted by the Germans intensified from 1935. The problems of radiolocation and hence the establishment of the „radar” was in the highlight of interest among researchers. In 1937 the „Gema” factory manufactured the FREYA device with its range of 35-40 kilometres. From 1938 the „Telefunken” company started experiments with WÜRZBURG radar family and later they started their production.

In Hungary experiments went on from the 30's. In the labs of the Tungstram dr. Bay Zoltán (1900-1992) (3. Dr. Bay Zoltán was one of the prominent members of the Hungarian science. Before the age of 30, he became a teacher of theoretical physics in Germany. In the University of Szeged he worked as a professor of theoretical physics until 1936 when he was invited to be the leader of the Tungstram laboratory. After the World War he became even more famous in the international scientific life with his experiments, such as the measurement of distance between the earth and the moon by microwave technology, etc.)

There was no production of independent locator yet, so Hungary needed German import and support.

For effective air defence Germany manufactured locators for four different types of tasks, for the air attack warnings, for the fire of the air defence artillery, for fighters fire and as equipment for aircraft (night fighters). We were interested in the whole spectrum of the system, because a unified system of domestic air defence could not function with the lack of any elements. It was probable that the expected activities- the worsening threat of air attacks against Hungary- would increase the importance of the night time fighter activities and the necessity of the effectiveness of the air defence artillery. It was also connected with this problem that the

population would be alarmed and informed at the right time.

The Hungarian Royal Military Institute wanted to introduce domestic production and design. In the summer of 1942 the institute proposed to start the experiments. Naturally, the institute didn't refrain from foreign procurements, but they were considered supplementary until self-supply was established. In September the director of the institute reported to the Chief of Staff and the Minister of Defence. He recommended domestic production, independently from Germany. The Minister of Defence, following his personal discussion with Dr. Bay, asked him to work out the theory of radar technology for the Hungarian army and to perform the basic experiments. So the military leadership accepted the proposals and they provided 150000 pengő (Hungarian currency of that time) for the project. This money was distributed among the members of the team which consisted of eight engineers, a physics teacher and about ten technicians, led by Dr. Bay. So there were enough finances for the Hungarian far- distance reconnaissance locator program. (It was based on FREYA type, its design, production and its name was first VIKTOR, then SAS.) The manufacturing of the radar soon started. The production of four pieces was planned and the Ministry of Defence provided 400 000 pengős. Genius professor Bay and his team did an excellent job. Though they had to work with triode transmitting valves- they were familiar with the magnetron and klystron theory- but there was not enough time and money for the domestic production. Even with these obstacles they managed to produce excellent devices. The practical work was performed by dr. Istvánffy Edvin, the director of STANDARD and his team.

In December 1942, with the leadership of Major General Hellebronth Vilmos, a group of

Hungarian specialists travelled to Germany to study locators. The Chief of the Air Force reported the following after his discussions with General Milch:

There were two basic types mentioned which were necessary to deploy:

Search locator „FREYA” (reconnaissance range 120-300 kms)

Air defence fire delivery locator „little WÜRZBURG,, or „WÜRZBURG- DORA,, (working range about 30 kms)

Fighter detection locator „the big WÜRZBURG,, or „WÜRZBURG- RIESE,, (reconnaissance range 40-75kms)

Fighter instrument „LICHTENSTEIN,, (rece range about 3 kms)

General Hellebronth, besides immediate Hungarian needs (1 piece of FREYA, 2 pieces WÜRZBURG – RIESE and 4 pieces of WÜRZBURG- DORA) announced our further requests, which were 4 pieces of FREYA, 8 pieces of WÜRZBURG-RIESE and 30 pieces WÜRZBURG-DORA, together with the possibility to participate in the production of locators and their parts. Mainly, the Hungarian industry would be capable to produce transmission valves and electric parts.

With the leadership of Colonel Dr. Jáky József, there was a two-day visit at the „Luftwaffen – befelaha-ber – Mitte „ firm. His report was not too optimistic. His task was to study the German radio measuring system, its production, and also to choose the necessary types for us, and he gave a more detailed description of the examined locators. The Colonel mentioned in his report that the answers he got to his questions were often evasive or exaggerated or too general. As it turned out later, the parameters of the devices were quite different from those that the Germans gave. More or less, they gave the data found in table number 1.

These numbers were corrected later. The other task of Jáky and his group, besides requesting equipment from General Hellenbronth, was to ask for equipment for domestic training. They were established earlier as 2 pieces of search, 2 pieces of air

defence fire delivery and 8-10 pieces fighter detection locators.

It was obvious that the Hungarian requests seemed exaggerated for the Germans who needed all their locators due to the intensifying allied bombings, but if we wanted to obtain an effective rece system, we really needed to get serious quantity of those.

By the beginning of 1943 the Reichslufwehr Ministry accepted an order for 1 search, 2 fighter detection and 4 fire delivery locators. Naturally it did not satisfy the needs of the Hungarian Command and the needs of other specialists. So a decision was made that an independent design and production should be introduced. The work of the Bay team was considered very successful, especially with the search and distance rece locators. The development of the other three types was also necessary. So they decided to strengthen this area as well.

On the 5th of May, 1943 the Minister of Defence tasked Dr. Jáky to lead the establishment and the production of the Hungarian locator. He was subordinated directly to the Deputy Minister of Defence. He was also tasked with involvement of the country's radio industry and electric engineering in the task. The Bay group's deadline of experiments and development was the end of 1943 and the mass production was to start in the following year. He got a definite task to involve, if necessary, other industries, such as the heavy industry and the precision mechanics industry in his work, following agreements with the MoD. He was also responsible for the development, establishment of the signal network of the locator system, as well as supervision and coordination of electronics that remained from the German import. He was also responsible for the supervision of the project's finances. His tasks and authority was widespread, but the complexity and the importance of the task required it. This choice of the person for that task proved to be perfect. Choosing Jáky provided an excellent organiser, a leader who had independent concepts, great knowledge for the development of the Hungarian locator system.



"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA



"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2013
Brasov, 23-25 May 2013

The Bay group prepared the plans for the Hungarian FREYA and its production started in the same year. Experiments with locators for air defence artillery and fighters continued. It was necessary since as it turned out, we couldn't expect any supplies from abroad.

On the 12th of February the German air defence attaché in Budapest informed the 5th division of the MoD that by April 3 the Germans will deliver 3 air defence artillery locators, and by May one search and 2 fighter detection locators for the Hungarian army. There was also an agreement about the training of the necessary staff. In the 1st phase the acquired or manufactured locators were to be used as follows:

Budapest would get 4 FREYAs, Balaton 3, Miskolc 3 Győr 3, Lispe 1, Szolnok 3 pieces.

For night time fighter missions 5 fighter cells which need 5 FREYAs and 10 WÜRZBURG-FRIESEs

For air defence batteries are 45 WÜRZBURG-DORAs.

In the course of the following developments the entire territory of the country was to be covered with 27-30 FREYAs and they would also provide recce across the borders as well as deployment of further 16 fighter cells (with 1 FREYA and 2 WÜRZBURG-Rs per cell). For the expected air defence batteries further 20 WÜRZBURG-Ds were planned.

In May the Germans gave the Hungarians 3 WÜRZBURG-Ds for the air defence artillery and further 2 in November. The system of locator qualification was prepared, and it was proposed to start the team trial of the three devices that arrived in the spring at the air defence district in Budapest.

The STANDARD Company had already mentioned to the MoD that with their existing capacity they would not be able to manufacture the necessary devices by 1944/1945. The order of the MoD provided 6

million pengos for 1944 and 10 million for 1945. There was a need for a new factory block and they asked for a loan of about 4 million pengos from the defence cabinet. The factory was planned to be built in the surroundings of Budapest or some other big industrial city. As a necessity for the production, about a thousand workers were hired. The 17/B department of the MoD, following the discussions with Colonel Dr. Jaky in November decided to provide the hall of the bus garage in Kelenfold, together with 2 million pengos as a loan. The deadline of the establishment was the middle of 1944. The MoD accepted the proposal to pay the loan in parts until the end of 1945. They introduced the present state of the production and the expected outcome.

In May and in the beginning of June Colonel Jaky reported to the Commanding Staff about the work he had done in his field of responsibility. The group led by Dr. Bay showed serious results both in preparation in manufacturing and in experimenting. On the one hand, with the construction their production was based on well-known ideas, on the other hand, their production introduced their own independent procedures that were based on their experiments, which caught the attention of the Germans, too. So, for example the reconnaissance range of the SAS was longer than that of the FREYA. On the roof of the building of the Egyesult Izzo they created a new research laboratory and they managed to achieve significant results in the development of cathode ray valves. The productions of both the transmission and reception valves were at a stage of starting their mass production. The productions of the Hungarian designed locators were quick. The „general arraignment” drawing of the BORBALA artillery locator was ready. Colonel Jaky tasked the GANZ and the GAMMA with the mechanical construction.

He thought it possible that the Hungarian industry would be able to produce one piece for the beginning of the next year. The work on the fighter guidance locator BAGOLY was also going well. The BAGOLY and the BORBALA were different only in their mechanical build-up, their electric set-up was almost the same. The biggest difference was in the size of the parabola mirror. Jaky also tasked other Hungarian firms with mechanical work of the fighter guidance locator. This task was given to the WAGON and GEPGYAR in Győr and the MAVAG. In his opinion the experimental production could have started in August- September. Out of the 4 search, distance recece locators that were ordered at the end of 1942 1 piece was produced by the 1st of July. It was considered an experimental one and they wanted to modify the 3 devices during the undergoing production based on their findings. The SAS was capable for 60 kms of recece distance, but Jaky thought that the distance could be extended to 100 kms and even further. As it turned out later, his prognosis was correct. He expected the next device to be ready by September and the 4th one by the end of the year.

The Gneral Staff insisted to start the design work on the Hungarian radar TURUL to be fitted into fighters. It was done in the PHILIPS factory, but mainly only in theory. In the report it was also mentioned that if they get the necessary support, mainly for factory capacities, then the mass production could be started in the second half of the year. It is true that Colonel Jaky also emphasized that the Hungarian factories, not only the STANDARD but also the industrial units producing mechanical and electric elements, needed to be developed. He considered that very important because in his opinion the Germans established the prices of locators as unrealistically high.

Eventually he informed the General Staff about the possibilities of the Hungarian production (in case his suggestions were accepted) about the expected and necessary German delivery, as well as the expenses in connection with the locators in the following 2 and half years.

The expected expenses were very high, though. For 1943 it meant about 13 and half million pengos with all equipment, supplies, with the locator premises, and by 1944 72 million, by 1945 57 million pengos. Unfortunately, in spite of the existence of the designs and the intentions for the production there were no finances and production capacity. And as it soon turned out there was no sufficient time, either.

By August Col. Jaky prepared the network for instalment of the search and artillery locators for the entire territory of the country, which he coordinated with the Commander of the Air Defence and he presented the plan to the General Staff. In his opinion it was necessary to establish a recece and an artillery system in the country. As a first step he proposed to establish 8 SAS and FREYAs. He recommended installing the search locators in pairs, since a device of this type was able to search in 225 degree radius. So they would be capable to do circular recece from all positions, in the directions of danger even overfolding could be provided. The establishment of a position was quite expensive, it cost about 1 and a half million pengos. In perspective he planned to establish a system that would provide extension of the radio location field over 100 kms, out of the borders of the country. Besides the search devices he recommended to deploy 2-2 pieces of BAGOLY and WURZBURG-Rs because from technical point they did not cost extra (10 000 pengos). He also planned the first phase of the deployment of the artillery fire delivery locators. He recommended deploying 4 locator bases for the Budapest air defence fire system, 2 for Győr, 2 to Veszprem, 2 to Szolnok, 2 to Miskolc and 2 to Lipse. He also worked out the organisation of the night time fighter guidance system. He needed further 18 plants. For the effective reconnaissance, fire delivery and fighter location he needed 40 air defence radio measuring (LRB) devices.

In September 1943 the second modified version of the SAS locator was ready at STANDARD. On the 2nd of November Jaky reported to the General Staff that there were 2 Hungarian- produced search locators



"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA



"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2013
Brasov, 23-25 May 2013

available. One of them was deployed at Janos Mountain. The locator was experimental, further devices would be modified on its basis. It was also used for training purposes at home. The place of deployment was not a proper one, so Jaky recommended Sari to be the next place. From there SAS was capable to lead the 3 WURZBURG-Ds of the fire systems in Budapest. The Sari plant was ready by December and started its work on the 20th. The second domestically produced locator was designed for night time fighter detection. There was an argument about where to deploy the device. They recommended Csorvanyos, then Felsoerdo, but the General Staff did not support these locations. Then Terecske and Jazskiser came up as a solution, so taking into consideration the aspect of time the decision was made for the second location. That locator and the plant started to work in the beginning of 1944. The SAS worked perfectly and in good conditions it was able to detect targets in the range of even 500 kms. By the end of the year the „air defence radio measurement artillery/ fighter” plant was in working order (its device was the FREYA from German import) in Dunapentele. Colonel Jaky proposed a „fly in „ of the locator and its deployment from the 1st of December.

The signal network of the plant was also arranged. According to the decision of the General Staff the locator in Dunapentele was also used for long-distance recce, its „switching on „ was allowed only in exceptional situations. For fighter guidance the 2 available WURZBURG-Rs were deployed in the same district. In December the Germans gave the next 2 FREYAs to Hungary.

But by the end of 1943 the plants only in Sari and Dunapentele had worked. In October Colonel Jaky ordered an establishment of a further LRB/V plant near Jazskiser. He wanted to deploy there the SAS, the second Hungarian

search and long-distance recce locator for fighter guidance. The production of the Hungarian BORBALA was also in process at STANDARD but the production of the 3 locators stopped with the German occupation. But according to the experiments the locators performed their tasks perfectly, with great mobility, since their equipment was mounted on the 36M air defence cannon. The radars built into fighters and aircraft were only in the phase of design or in the beginning of production. In 1943 the entire domestic air defence observation and warning system got under the authority of „Air Defence Forces Command”. By the end of the year the air defence had - though not all devices were deployed - 4 search (two of which were domestically produced SAS), 5 WURZBURG-DORA air defence artillery fire delivery (all German products) and 2 WURZBURG- RIESE fighter guidance (also German) locators. One piece of the search locators was planned to be used for long-distance recce, 2 for fighter guidance, 1 for air defence artillery fire delivery. So the army had a system of devices that could have provided the basis for the establishment of the modern air defence. But the chance was lost due to the events of the war and partially, of the German occupation.

On the 23rd of November both General Zoltan Harmos and Colonel Jaky asked for the extension of the work of the Bay team until the 31st of December 1944. In their opinion, at least one more year was necessary to continue and end the research, trials and planning. As a result, General Harmos said the following: „ of the 3 locator types we would have our own by 1944”. So the industrial capacity is capable to satisfy the need for the production of 300 locators. In his opinion it was impossible to rely on the German import, since they delivered only 6 radars so far. Besides, he also emphasized that the devices

planned and produced by the Bay team, such as the transmitting valve, the reinforcing valve, diode, the low performance vibration valve, cathode ray valve were excellent.

The reason for the extension request was that there were still a lot of unsolved matters. These were the problems in disturbance protection, the friendly aircraft detection system and the wave ranged devices. He emphasized the unique credits of Dr. Bay and since the professor did not accept any payment, not even money for his expenses, he proposed to give him an award.

From the 2nd half of 1943 the Germans started to plan the deployment of many recce and fighter detection locators to Hungary, but for their own purposes. The Hungarian recommendation for common use of these devices was probably not accepted.

After the German occupation on the 19th of March, the Bay team was involved, after working on the development of the Hungarian locator, in the preparation for the mass production of a universal German military microwave valve. Colonel Jaky Jozsef, the genius organiser, lost his life during the air attacks against Hungary.

The Hungarian civilian and military leaders tried to supply the Hungarian military with proper equipment according to the given circumstances and opportunities. This proved to be successful. It was only in the middle of the next decade that Hungary and its army had the chance to obtain excellent equipment like this.

Conclusion

It would also be useful in our days if the „small states „ paid more attention to this system of organisation and equipment so effective for security. Even though there is little chance for a traditional war in Europe, but the events of 9/11 demonstrated that there are new dimensions of air threats.

Hungary and the Hungarian defence forces must have the following systems for the proper security and defence:

1. A basic radar system that continuously provides the minimally needed coverage. This can be achieved by the deployment and usage of 3 high performance NATO radars.

2. A mobile radar system. With its help it would be possible to extend the radio location area in a given direction, with given requirements.

3. The most critical part of the system is the lack of air reconnaissance. The Hungarian Defence Forces do not possess their own satellite system; there are no AWACS, not even „balloon” radar. The fulfilment of these necessities is not expected in the near future.

4. The database of the civilian air traffic control has been used but the recce of the air combat equipment cannot be based on a secondary system whose identification capability, disturbance defence is highly limited from the military point of view, not to mention the fixed location (Korishegy, Puspokladany, Ferihegy)

5. The HDF has the command point and the system necessary for the data collection, processing and forwarding of the above-mentioned elements. Continuous modernisation is necessary in this area as well.

References

Dr. Barczy Zoltán: A magyar légvédelmi tüzérség 1943-ban a radar bevezetése idején, *Hadtörténeti Közlemények*, 1977/2 222-241. oldal

Dr. Barczy Zoltán: A magyar légvédelmi tüzérség fejlődése a Horthy korszakban, *Tanulmánygyűjtemény*, *Hadtörténeti Levéltár*

Bay Zoltán: *Az élet erősebb*, Debrecen–Budapest, 1990.

Bay Zoltán: *Válogatott tanulmányok*, Gondolat, Budapest, 1988.

Bekker Cajus: *Augen durch Nacht und Nebel (Die Radar-story)*, Oldenburg, 1958.

M. Szabó Miklós: *A magyar királyi honvéd légierő a második világháborúban*, Zrínyi Kiadó, Budapest, 1987.

Móra László: *Radar harcászati alkalmazása*, *Honvéd*, 1947/6 21-33. oldal

Nagyváradai Sándor–M. Szabó Miklós–

Winkler László: *Fejezetek a Magyar katonai*



"HENRI COANDA"
AIR FORCE ACADEMY
ROMANIA



"GENERAL M.R. STEFANIK"
ARMED FORCES ACADEMY
SLOVAK REPUBLIC

INTERNATIONAL CONFERENCE of SCIENTIFIC PAPER
AFASES 2013
Brasov, 23-25 May 2013

repülés történetéből, Műszaki könyvkiadó,
Budapest, 1986.

Pataky Iván–Rozsos László–Sárhidai Gyula:
Légiháború Magyarország felett, Zrínyi kiadó,
1992.

Sifter László: Magyar radarkészülékek,
Honvéd 1948/1. 48-49. oldal

Dr. Varga József: A légvédelmi tüzérség
története a kezdetektől a második világháború
végéig, Magyar Honvédség Légvédelmi
Rakéta- és Tüzérfőnökség kiadványa, 1996.