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Elena Tverytnykova
ORCID 0000-0001-6288-7362
National Technical University "Kharkiv Polytechnic Institute"
(Kharkiv, Ukraine)
tveekhpi@ukr.net

Olena Voitiuk
ORCID 0000-0002-7670-6849
Zhytomyr Polytechnic State University
(Zhytomyr, Ukraine)
helen_zt24@ukr.net

Academician V. H. Serheiev – Control System Designer, Founder of the Scientific and Design School, Honored Citizen of Kharkiv (on His 110th Birthday)

Abstract

March 5, 2024 marks the 110th birthday of Volodymyr Hryhorovych Serheiev, an outstanding scientist, chief designer of control systems for strategic combat missiles, launch vehicles, spacecraft and transport modules of orbital complexes, Academician of the National Academy of Sciences of Ukraine and an Honored Citizen of Kharkiv. Despite his significant scientific achievements in the field of rocket and space engineering, the silhouette of V. H. Serheiev is hardly reflected in the modern history of science.

Based on representative sources, the article highlights the main achievements of the scientist in the field of dynamics of automatic control systems and the design of rocket and space engineering control systems. The summary of the most prominent space projects is based on the memories of witnesses and direct participants.

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The personal qualities of V. H. Serheiev as the head of the Special Design Office No. 692 are noted. The historical retrospective describes technical developments and inventions meant to improve the control systems of intercontinental ballistic missiles R-16, R-16У, R-36, R-36П, R-36 orbital, R-36M, R-36M UTTH, UR-100N, UR-100HU, and R-36M2. At the initiative of V. H. Serheiev, complex stands were developed, which worked non-stop in all modes of operation of the necessary equipment and solved complex scientific and technical problems of creating an on-board digital computer. V. H. Serheiev was the chief control system designer of space launch vehicles Kosmos, Kosmos-2, Cyclone-2, and Cyclone-3 and Tselina series spacecraft. The article features innovative solutions implemented under Serheiev's leadership during the creation of the Energia launch vehicle, supply vehicles of the Almaz space rocket system and target orbital modules of the Saliut and Myr space stations, and international launch vehicles Dnipro, Rokit and Strila.

The article considers the issues of V. H. Serheiev's direct participation in the organization of the training system for scientific personnel in the relevant specialties at Ukraine's higher education institutions, as well as the development of international cooperation. It is substantiated that the scientist created one of the leading science and construction schools for the development of control systems for rocket and space technology, which is internationally recognized.

The authors emphasize that V. H. Serheiev devoted a lot of attention to people. At his initiative and with his support, a district named after the founder of aerodynamics, M. Y. Zhukovskyi, was created in Kharkiv for the employees of "Hartron" enterprise. The district was not far from the enterprise and had a well-developed infrastructure, such as kindergartens, schools, shops, a swimming pool and a complex of residential buildings.

Keywords: *control systems, rocket and space engineering, history of science, source base, biography, international cooperation, Volodymyr Serheiev, training of scientific personnel, Ukraine*

Akademik Wołodymyr Hryhorowycz Serheiev – projektant systemów sterowania, założyciel szkoły naukowo-projektowej, honorowy obywatel Charkowa (w 110. rocznicę urodzin)

Abstrakt

5 marca 2024 r. przypadała 110. rocznica urodzin Wołodymyra Hryhorowycza Serheieva, wybitnego naukowca, głównego projektanta systemów sterowania strategicznych rakiet bojowych, rakiet nośnych, statków kosmicznych i modułów transportowych kompleksów orbitalnych, akademika Narodowej Akademii Nauk Ukrainy, honorowego obywatela Charkowa. Znaczące osiągnięcia naukowe V.H. Serheieva nie znajdują jednak odpowiedniego miejsca we współczesnej historii nauki, a jego biografia nie została szeroko opracowana.

Artykuł, oparty na wykorzystaniu reprezentatywnej bazy źródłowej, podkreśla główne osiągnięcia naukowca. Informacje o najważniejszych projektach kosmicznych zostały podsumowane na podstawie wspomnień obserwatorów i bezpośrednich uczestników tych wydarzeń.

Zwrócono uwagę na osobiste cechy V.H. Serheieva jako szefa Specjalnego Biura Projektowego-692. W retrospekcji historycznej opisano rozwój techniczny i wynalazki mające na celu ulepszenie systemów sterowania międzykontynentalnych rakiet balistycznych R-16, R-16У, R-36, R-36П, R-36 orbitalnych, R-36M, R-36M UTTH, UR-100N, UR-100HU, R-36M2. Z inicjatywy V.H. Serheieva opracowano kompleksowe stanowiska, które pracowały non-stop we wszystkich trybach pracy niezbędnego sprzętu i rozwiązywały złożone problemy naukowo-techniczne stworzenia pokładowego komputera cyfrowego. Naukowiec był głównym projektantem kosmicznych rakiet nośnych „Kosmos", „Kosmos-2", „Cyklon-2", „Cyklon-3" i statków kosmicznych serii „Tselina". Opisano cechy innowacyjnych rozwiązań, które zostały wdrożone pod kierownictwem naukowca podczas tworzenia rakiety nośnej „Energia", pojazdów dostawczych systemu rakiet kosmicznych „Almaz" i docelowych modułów orbitalnych stacji kosmicznych „Saliut" i „Myr", międzynarodowych rakiet nośnych „Dnipro", „Rokit" i „Strila".

W artykule rozważono kwestie bezpośredniego udziału V.H. Serheieva w organizacji systemu szkolenia personelu naukowego w odpowiednich specjalnościach w instytucjach szkolnictwa wyższego Ukrainy, a także rozwoju współpracy międzynarodowej. Uzasadniono, że naukowiec stworzył jedną z wiodących szkół naukowo-budowlanych w zakresie rozwoju systemów sterowania dla technologii rakietowej i kosmicznej, która jest uznawana na arenie międzynarodowej.

Autorzy podkreślają, że V.H. Serheiev poświęcił wiele uwagi ludziom. Z jego inicjatywy i przy jego wsparciu dla pracowników przedsiębiorstwa „Hartron"w Charkowie powstała dzielnica imienia założyciela aerodynamiki M.Ye. Żukowskiego. Znajdowała się w pobliżu przedsiębiorstwa iposiadała rozwiniętą infrastrukturę: przedszkola, szkoły, sklepy, basen i kompleks budynków mieszkalnych.

Słowa kluczowe: *systemy sterowania, inżynieria rakietowa i kosmiczna, historia nauki, baza źródłowa, biografia, współpraca międzynarodowa, Volodymyr Serheiev, szkolenie kadry naukowej, Ukraina*

1. Introduction

The defense industry has always been a key area of Ukrainian policy, which has become especially relevant in the context of current geopolitical challenges. Amid the escalating conflict between Ukraine and the Russian Federation, the development of the aerospace industry is of great importance for ensuring national security and advancing technologies in the field of innovative missile engineering, electronic warfare systems and unmanned aerial vehicles. Modern global defense projects open up opportunities for Ukrainian scientists and specialists in the context of international scientific cooperation.

The history of Ukrainian rocketry has a long tradition. Ukrainian designers have made a significant contribution to the development of rocket and space science and technology. The relevance of their achievements is the basis for modern space programs and research around the world. The development of modern space science and technology and innovative technologies is based on Ukraine's previous achievements in this field. Given the new challenges of global science and modern technologies, historical research into the contribution of Ukrainian scientists, enterprises, research and educational institutions to the development of the rocket and space industry is urgent.

The achievements of such well-known designers as S. P. Korolev, M. K. Yangel, V. S. Budnik, V. F. Utkin, S. M. Konyukhov, V. P. Glushko, O. M. Makarov, V. M. Chelomei, V. M. Kovtunenko and others have been recognized worldwide. Therefore, the silhouette of the outstanding constructor Volodymyr Hryhorovych Serheiev is considered to be interesting for a more comprehensive study. His contribution to the development of rocket and space engineering control systems is recognized as a significant achievement, marked by high scientific and technical competences. For the first time in Ukraine, control systems were created on the basis of on-board computing equipment. This made it possible to solve tasks with a high degree of accuracy and reliability. In terms of the technical level, the control systems created under the leadership of V. H. Serheiev were on par with the best foreign models, and in some respects surpassed them. V. H. Serheiev was the chief designer of high performance control systems for four generations of strategic combat missile systems, three generations of space missile systems and many spacecraft.

V. H. Serheiev's professional activity has rarely been studied in the historiography of the Soviet period. The specifics of his work, which was directly related to the country's security, prevented the scientist's activities from being more widely known. The chief designer V.H. Serheiev was not mentioned in the press or in television reports. It was only in the 1990s that some publications appeared, with fragmentary coverage of Serheiev's scientific work. Subsequently, materials were published about the creation of rocket and space technologies in Ukraine and the activities of the Hartron joint stock company, which listed the scientist as its chief designer.[1] There are several publications dedicated to the 100th birthday of Serheiev.[2] Therefore, the authors consider it necessary to highlight new archival documents in Ukrainian historiography for a more thorough overview of the scientist's activities. The research was based on the personal diaries of Hartron staff, memoirs, interviews with veterans of the company, and unique photographs from the collection of eyewitnesses who worked directly with Serheiev at various stages of the development of rocket and space equipment.

The article uses general scientific and special historical methods (retrospective, problematic and chronological, comparative historical, analysis, synthesis and classification).

The purpose of this article is to conduct a holistic historical and scientific analysis and a comprehensive assessment of Serheiev's theoretical and practical contribution to the development of control systems for world-class rocket and space technology.

2. Biographical information

V. H. Serheiev was born on March 5, 1914 into a family of workers (Fig. 1). In 1930, he graduated from the 7th grade of a specialized professional and technical school at the Moscow Electric Plant. Volodymyr Hryhorovych began his career in 1932 as a mechanic at a sewing factory in Moscow. In the years 1934–1940, he was studying at the Faculty of Wired Communications at the Moscow Institute of Communication Engineers. From June 1941 to March 1947, he served in the army, where he worked as a technician, engineer, and commander of a separate linear communications battalion. He participated in heavy combat on the frontlines of World War II and he was awarded state orders and medals for his military merits. His outstanding achievements in the development of rocket and space technologies earned him state honors and four State Awards.

From June 1947 to November 1960, V. H. Serheiev worked at Scientific Research Institute No. 885 of the Ministry of the Communications Industry of the USSR where he was directly involved in the development of special electronic devices for rockets and the first artificial Earth satellites.

In 1960, he became the chief designer at Special Design Office No. 692 (later renamed Elektropryladobudovannia Design Bureau). For 26 years, until 1986, he successfully led the enterprise, gaining significant success and recognition at the state level. Thanks to his tireless work and outstanding abilities, a number of exceptional projects in the country's rocket and space industry were implemented. In 1992, the company was renamed Joint Stock Company "Hartron". Serheiev was the enterprise's scientific consultant until the end of his life.

In 1968, Serheiev defended his doctoral dissertation, and in 1982, he became an academician of the National Academy of Sciences of Ukraine.[3]

Fig. 1. Academician Volodymyr Hryhorovych Serheiev.
Source: AM of the JSC "Hartron" cat. no. 15.

[1] Zavalishin 1997; Zlatkin (eds.) 2006; Gonchar 2008; Aizenberg 2010; Tverytnykova, Belous 2011.
[2] Vakhno 2014; Gorbulin, Vasilenko, Mitrakhov 2014; Gorelova, Ivanov, Larin, Obolenskaya 2014.
[3] Archive of the museum of the Joint Stock Company "Hartron" (hereafter AM of the JSC "Hartron") cat. no. 21.

3. The role of V. H. Serheiev in the creation of the control systems for the first Soviet ballistic missiles

The basis for the development of rocketry in the USSR during the post-war reconstruction period was the Resolution of the Council of Ministers of the USSR No. 1017-419 dated 05/13/1946, which provided for the establishment of a Special Committee on Rocketry to carry out coordination and organization. According to the next resolution of the Council of Ministers of the USSR No. 3539-1646 dated 09/21/1951, the “Komunar” enterprise in Kharkiv was reoriented to the production of on-board and ground equipment for missile control systems. In fact, this date marks the beginning of Kharkiv’s rocket and space history. Initially, the development of the equipment was based on documentation of the Scientific Research Institute (SRI-885) headed by M. O. Pilyugin. Already in 1952, a special design bureau, SRI-885, was established at the enterprise to provide scientific support for the production of complex equipment. Based on the documentation of SRI-885, on-board equipment and control systems for R-1, R-2, R-5, and R-7 missiles were manufactured.[4]

Since 1947, V. H. Serheiev worked at Scientific Research Institute-885 as an engineer, junior researcher, group leader, and deputy head of the department. Later, he headed the laboratory of rocket centre of mass stabilization. This laboratory was a structural unit of the complex for the development of autonomous control systems, where normal and lateral stabilization systems were developed. Under the leadership of V. H. Serheiev, the issues of increasing the sensitivity of measuring elements, reducing the lateral drift of the rocket and compensating for it with on-board instruments of the autonomous control system were resolved. The successful completion of this scientific task earned him the degree of Candidate of Technical Sciences (without defending his dissertation) on February 28, 1959.[5]

In 1957, the world’s first intercontinental ballistic missile R-7 (8K71) was successfully launched. During its development, a number of new principles were used in its control system, in particular the system of normal and lateral stabilization of the centre of mass, developed by V. H. Serheiev’s group, was tested for the first time. With Serheiev’s participation, a new control method was introduced: the ‘rigid trajectory’ method. Under the direction of V. H. Serheiev, the laboratory team created the normal and lateral subsystems for stabilizing the motion of the missile’s center of mass, the apparent velocity control system, and the tank emptying system. They contributed to the possibility to control the missile with the required flight accuracy without the use of range and lateral radio control systems. Subsequently, this made it possible, under certain conditions, to abandon the use of radio control systems during launches of ballistic missiles and launch vehicles of artificial Earth satellites.[6]

The use of the measuring and converting head, developed and improved with the participation of V. H. Serheiev, made it possible to solve a number of complex problems related to ensuring the stabilization of the rocket flight in the active area, and improving the accuracy characteristics of autonomous rocket control systems.[7]

On October 4, 1957, the R-7 intercontinental ballistic missile launched the first artificial Earth satellite into orbit. In 1957, V. H. Serheiev was awarded the Lenin Prize for the creation of a lateral correction device for the autonomous control system of the R-7 intercontinental ballistic missile.

In the 1960s, the USSR’s effective armament to counter the US Thor and Atlas missiles required the creation of an intercontinental ballistic missile suited for long periods of combat duty, with a range of up to 12,000 km and a fully autonomous control system. Therefore, the

[4] Larin, Gutnyk, Tkachenko, Horielova 2021, p. 85.
[5] Gorbulin, Vasilenko, Mitrakhov 2014, p. 91.
[6] Vakhno 2014, pp. 55, 59-61.
[7] Zvonkova, Mitrakhov 2014, p. 129.

control system of the R-7 missile required certain modifications to achieve the required accuracy.

To solve these problems, a group of enterprises was established in Ukraine, headed by the Special Design Office No. 586 in Dnipro (now the Yuzhnoye State Design Office), headed by M. K. Yangel. It was Yangel who initiated the creation of a new organization in Kharkiv in 1959, namely Special Design Office No. 692 (headed by B. M. Konoplyov), which was important for the development of the Ukrainian missile industry (Fig. 2).

Fig. 2. V.H. Serheiev and M.K. Yangel. Source: Zlatkin 2006, p. 186.

The scientific staff of the main integrated research and development team of the Special Design Office No. 692 (SDO-692) were engaged in the development of control systems, including an automatic stabilization system for on-board electrical automation and ground test launch equipment, for missiles designed by specialists of the SDO-586. One of their first joint projects was a state-of-the-art intercontinental ballistic missile, unified for open ground launch and launch from mine launchers. A. M. Hinzburg was appointed as the chief designer of systems and equipment for it at the SDO-692.

On October 24, 1960, during flight tests of the R-16 intercontinental ballistic missile, tragic events occurred at the Baikonur Cosmodrome — the worst large-scale disaster in the history of Soviet rocketry, with many human victims. It was the result of a combination of circumstances and technical shortcomings. According to various sources, the death toll ranged from 70 to 120 people. One of the victims was the head of the Special Design Office No. 692, B. M. Konoplyov (Fig. 3).

Fig. 3. Stele monument to the victims of the Baikonur disaster of October 24, 1960. Source: AM of the JSC "Hartron". cat. no. 15.

The analysis of the accident consequences confirmed the need to create a reliable system for designing, testing, manufacturing and operating rocket and space rocket systems and gave impetus to the creation of an appropriate regulatory framework for rocketry. The technology for launch preparation and the launch complex equipment were further developed.[8]

After the tragic events of November 16, 1960, V. H. Serheiev was appointed to the position of Chief Director and Chief Designer of the Special Design Office No. 692. He had vast experience in research and development work gained during his time at Scientific Research Institute No. 885. In his memoirs, Borys Mykhailovych Konoriev, head of Department No. 35 of the "Elektroprylad" Research and Production Enterprise, recalled:

> V. H. Serheiev was a representative of a pleiad of outstanding scientists and organizers, chief designers — creators of new unprecedentedly complex control systems, not inferior to, and in some cases superior to, the world's best examples of unique (one-of-a-kind) rocket and space technology objects of the second half of the last century. His appointment as Chief Designer and Chief Engineer of the SDO-692 proved to be successful, he showed great courage and excellent judgment for the right decisions (in that difficult period for the enterprise).[9]

At that time, the Special Design Office No. 692 consisted of two complexes: the complex of autonomous control systems (headed by Chief Designer A. M. Hinzburg) and the complex of radio control (headed by G. O. Baranovskyi). V. H. Serheiev completed the organizational and structural reform of the enterprise as soon as possible and clearly defined the functional responsibilities of additional departments: scientific and theoretical (headed by D. F. Klym); finished devices of autonomous control systems (headed by A. M. Shestopal); complex tests (headed by U. M. Fedotenkov); and development of design documentation (headed by P. M. Sorokyn). In 1961, the experimental plant "Elektroprylad" was established. A. P. Kovalenko was appointed as the enterprise's director and deputy head.[10]

At the initiative of V. H. Serheiev, the issue of building a missile control system was revised, and its 'weak elements' were identified and finalized. The documentation for the control system was substantially and thoroughly revised to improve safety and reliability, and the scientist organized a powerful instrumentation production facility to create inertial rocket flight control systems.[11]

Thanks to his perseverance and, of course, his organizational talent, V. H. Serheiev managed to create all the necessary conditions for the creation of a technology at the enterprise to ensure the full development of the systems created, safety and trouble-free operation of the most critical works, including the installation of missiles on combat duty. The complex stands created on the initiative of the scientist (Fig. 4), which reproduced real missile flight conditions around the clock, modeled the movement of the entire object and could work out all modes of equipment operation. They became the main tool at the Special Design Bureau. For this purpose, a special team of experienced specialists was created (Fig. 5). [12]

On February 2, 1961, successful flight tests of the R-16 (8K64) autonomously guided intercontinental ballistic missile were conducted. In 1967, the USSR State Award for the creation of this missile was awarded to V. H. Serheiev, Y. Y. Aizenberg and V. K. Kopyl. On June 17, 1961, Serheiev was awarded the title of Hero of Socialist Labor for his outstanding achievements in the technical support of the launch of the world's first spacecraft with a human on board.[13]

[8] Degtyarev 2014, p. 115.
[9] Vakhno 2014, p. 277.
[10] Vakhno 2014, p. 82.
[11] Shudrik 2014, p. 166.
[12] AM of the JSC "Hartron" cat. no. 10; AM of the JSC "Hartron" cat. no. 5.
[13] Paton 2015, p. 51.

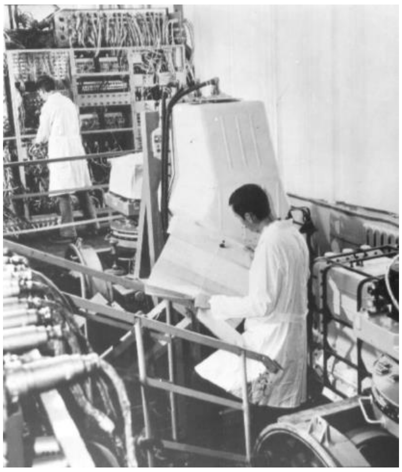

Fig. 4. Active complex stand. Source: AM of the JSC “Hartron”. cat. no. 15.

Fig. 5. Workplace of the operators of 11KA25 integrated control system stand. Source: AM of the JSC “Hartron”. cat. no. 15.

For many years, the team of the Special Design Office No. 692, headed by V. H. Serheiev, was engaged in the development of increasingly sophisticated control systems for four generations of strategic combat missile systems and three generations of space missile systems. The systems were developed by Chief Designers M. K. Yangel and V. F. Utkin at the Special Design Office No. 586 (Yuzhnoye SDO), V. M. Chelomei at the Central Design Bureau of Mechanical Engineering, M. F. Reshetnyov at the Special Design Office No. 10 and V. P. Glushko at the Central Design Bureau of Power Engineering (Fig. 6).

Fig. 6. General designers: V. F. Utkin, V. P. Glushko, M. O. Pilyugin, and V. H. Serheiev, 1976. Source: A. Degtyarev 2014, p. 112.

4. The use of digital computers and computer systems in the creation of innovative control systems for rocket and space technology of the “Elektropryladobudovannia” Design Bureau

The staff of the design bureau were developing control systems for a number of the most important models of strategic missile systems. To increase the USSR’s nuclear missile potential compared to the United States, the R-36 (8K67) heavy two-stage intercontinental ballistic missile, the first orbital missile, the R-36 (8K69), and the R-36P (8K67P) were developed.[14]

Representatives of the “Hartron-Arcos” scientific and production enterprise, General Designer Y. Zlatkin and Head of the Department S.S. Koruma noted that:

[14] Horbulin, Koltachykhina, Khramov 2014, p. 91.

the existing analogue control system was not suitable for those missiles, so on the initiative of V. H. Serheiev and under his leadership, a permanent scientific and technical council was established. As a result, the necessary measures were identified for the development of a new missile control system and discrete equipment — counting and deciding devices — was created.[15]

The first rocket to use devices with digital principles of operation in its control system was the "Kosmos-2" rocket (11K65). Subsequently, the experience of using counting and deciding devices was used in the "Cyclone-2" (11K69), RT-20P (8K99) and "Cyclone-3" (11K68) rockets with full automation of prelaunch preparation and launch (Fig. 7).[16]

(11K69), Baikonur (11K68), Baikonur (8K99)

Fig. 7. "Cyclone-2" LV, "Cyclone-3" LV, RT-20P IBM. Source: Vakhno 2014.

In the early 1970s, missile systems were upgraded to R-36M and MR-UR100 with intercontinental ballistic missiles 15A14 (SS-18) and 15A15 (SS-17), respectively.[17] In addition to manufacturing the control system equipment for these missiles, the company created sets of equipment for missiles with a separable warhead.[18]

The "Elektropryladobudovannia" Design Bureau worked effectively to develop missile systems together with other Ukrainian enterprises, such as the "Pivdennyi Machine-Building Plant", "Kyiv Radio Plant", "Monolit", "Kommunar", "Elektroaparat", and "Kharkiv Shevchenko Instrument-Making Plant". JSC "Hartron" developed control systems for missile systems, including on-board electronic computers, and the plants mass-produced them. Since the late 1960s, these entities have formed a single production complex.[19]

The first control systems were built with analogue and electromechanical stabilization devices, and since 1964, with electronic counting and deciding devices. At the stage of creation and further production of electronic counting and deciding devices, the "Hartron" Research and Production Association (RPA) organized modern and powerful production of modules, multilayer printed circuit boards, and ferrite-core storage devices and solved complex scientific and technical problems such as ensuring interference immunity, high reliability, and on-board computer parameters suitable for a service life of 10 years or more[20]. At that time, the enterprise

[15] Vakhno 2014, p. 193.
[16] Zlatkin 2005, p. 59.
[17] Horbulin, Koltachykhina, Khramov 2014, p. 41.
[18] Archives of the CDAGO, f. 1, desc 24, case 711, p. 107.
[19] Zavalishin 1997, pp. 26–29.
[20] AM of the JSC "Hartron" cat. no. 10; AM of the JSC "Hartron" cat. no. 5.

employed talented scientists and engineers: V. P. Leonov, G. S. Bestan, D. M. Merzliakov, D. M. Smurnyi and others. The first head of the on-board equipment development complex established in 1962 was A. M. Shestopal, and later the unit was headed by A. I. Kryvonosov (1966–1992). In the years 1960–1986, the chief designer of control systems for missile systems was V. H. Serheiev.

The chief designer of on-board computer systems of the "Hartron" RPA, Doctor of Technical Sciences A. I. Kryvonosov noted that

> By the mid-1960s, it was clear that the principle of building control systems based on analogue and discrete counting and deciding devices had no prospects. Further improvement of the control of intercontinental ballistic missiles required a sharp increase in the amount of information processed on-board the missile in real time. It was also necessary to fundamentally change the ideology of routine inspections of missile systems, which was based on the use of complex and expensive mobile test equipment that was inconvenient to operate...[21]

Therefore, at a meeting in April 1967, General Director and Chief Designer V. H. Serheiev suggested discussing and resolving the issue of creating control systems with on-board electronic computers. All heads of leading departments — Y. E. Aizenberg, A. I. Kryvonosov, B. M. Konoriev, A. S. Gonchar and others — spoke in favor of using such electronic machines of their own design, as it was virtually impossible to make the necessary changes to the software of a 'foreign' machine. This would have dramatically slowed down the development of new control systems.[22]

Of course, the Cold War situation required the creation of a missile defense system with space-based elements for a preemptive nuclear strike. In other words, it was necessary to revitalize the work on creating innovative developments to counterbalance the developments of US missile scientists. In the 1960s, the US already had ballistic missiles and promising intercontinental missiles such as the solid-fuel Minuteman and liquid-fuel Titan II. Based on V. H. Serheiev's proposal, the ballistic department developed special equipment with control and homing functions, which helped to detect missiles and made it possible to make a defensive maneuver.

To this end, on the initiative of the scientist, the enterprise was restructured and departments were created to develop directly the on-board digital computer and its ground test and launch part, to determine the basic requirements for the computing characteristics of the machine and its architecture, and to determine the methods and means of processing its software and on-board computer systems.[23]

In 1968, the first experimental sample of the 1A100 on-board digital computer was tested on hybrid modules of the "Tropa-1" series. Six months later, its three-channel modification appeared on monolithic integrated circuits with a unified M4M processor (Fig. 8).

In order to ensure the small size and weight of electronic computers, the following emerged in the rocket and space industry: hybrid microassemblies of RAM control circuits, flat micromodules of matching devices with galvanic isolation and multilayer printed circuit boards, etc. It was the achievement of the Design Bureau team headed by V. H. Serheiev. In 1971, for the first time in the USSR, a new 15A14 rocket was launched with a control system that included an on-board electronic computer.[24]

[21] Zavalishin 1997, p. 68.
[22] Malynovskyi 2004, p. 106.
[23] Gorbulin, Vasilenko, Mitrakhov 2014, pp. 93–94.
[24] Malinovskii 1998, p. 51.

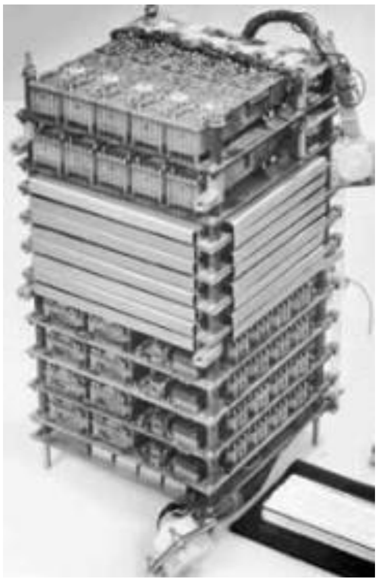

Fig. 8. The central processing unit of the M4M mainframe.
Source: Vakhno 2014, p. 133.

In 1976, work began on the R-36M UTTH (with improved tactical and technical characteristics) and the MR-UR100 UTTH missile systems with 15A18 and 15A16 intercontinental ballistic missiles (IBM). For the 15A18 missile, the latest 15F183 warhead with high-speed warheads with high-yield charges was developed (Fig. 9).

Fig. 9. Launch of the R-36M UTTH (15A18) "Dnipro".
Source: Degtyarev 2014, p. 414.

The upgrade of the control system of this main part by the specialists of the "Elektropryladobudovannia" Design Bureau consisted in implementing more complete control principles with a reduction of methodological errors to almost zero, as well as increasing the memory of the on-board electronic computer. In 1977–1979, during the flight tests of the MR-UR100 UTTH missile system, the main focus was on testing the latest control system developed under the leadership of V. H. Serheiev. This involved confirming the firing accuracy and testing the process of re-equipping the missile system for the upgraded 15A16 missile (Fig. 10).[25]

[25] Horbulin 2021, pp. 122–123.

Fig. 10. Chief Designer of Control Systems V. H. Serheiev, Chief Designer of the "Voevoda" IBM, General Designer of "Yuzhnoye" Design Office V. F. Utkin, 1979.
Source: A. Degtyarev 2014, p. 132.

In 1979, the 15A18 and 15A35 missiles with a unified on-board electronic computer were put into service. For the first time in the USSR, the technology of testing software and mathematical programs with the so-called 'electronic launch' was developed for their control systems; the flight of the missile and the functioning of its control system were simulated on a special complex stand using the "LECM-6" electronic computer. The control systems developed for missiles of the following modifications provided hitting a stadium-sized square at the maximum range; combat capability within the time required; autonomous and remote checking of the status of missile systems and launch; high operational reliability; protection against accidental and unauthorized launches; remote and automatic entry of the flight mission and re-aiming; individual guidance of warheads of the missile's main part to separate targets and cover (protection) of warheads with false targets; maintaining operability and precise targeting after a seismic impact on the launch position from a nuclear impact on the launch position area.[26]

In the early 1980s, to create effective measures to prevent the promoted multi-echelon air defense system of the United States, missile systems P-36M2 ("Voevoda") with the intercontinental ballistic missile 15A18M (Fig. 11) and RT-23 UTTH ("Molodets") with solid-fuel missiles SS-24 were developed. The control system of the R-36M2 missile system was developed by the team of the "Elektropryladobudovannia" Design Bureau on the basis of two high-performance digital computing systems ('on-board' and 'ground') of the new generation.[27]

Fig. 11. The R-36M2 (15A18M) "Voevoda" IBM.
Source: Vakhno 2014, p. 107.

[26] Shudrik 2014, p. 168.
[27] Horbulin 2021, p. 127.

In the years 1984–1988, the most difficult tasks for the team of the "Elektropryladobudovannia" Design Bureau were the development of a control system for SS-18 missiles and the creation of an on-board multi-machine computer complex for the "Energia" launch vehicle (Fig. 12). This complex solved the most complicated problems of stabilization, launch (taking into account emergency situations of controlling numerous units), emergency engine protection, and soft landing of the upper stages ("sidesteps"). At the same time, it was necessary to implement measures to provide fire and explosion safety in the complex's control system. A. I. Kryvonosov recalls:

> It required maximum effort from the executives and all specialists, working around the clock, seven days a week, often people spent the night at their workplaces. The most valuable reward for the work was two successful launches of the "Energia" launch vehicles and the successful field testing and commissioning of the SS-18 rocket. [28]

Fig. 12. Reusable transport space system "Energia-Buran".
Source: A. Degtyarev 2014, p. 176.

V. H. Serheiev was the chief designer of the control systems of the world's only intercontinental cruise missile "Meteorit" (3M25) with unique technical and tactical characteristics; it was a high-flying, long-range supersonic missile that was 'invisible' to detection and had three types of basing: ground (mobile missile complex), sea (submarine) and air (Tu-95MS aircraft). The peculiarity of the development of its control system was that the flight was carried out at high altitude, which made it impossible to use a terrain correction system. The designers managed to solve this problem — the world's first unique trajectory correction system based on radar maps of the area was thus developed.[29]

The control systems for R-36, R-36M, UR-100H, UR-100NU (Fig. 13) and R-36M2 missiles provided the required characteristics: firing accuracy; combat readiness of the complex in a given time; autonomous and remote checking of the status of missile systems and launch; high operational reliability, serviceability, and protection against accidental and unauthorized launches; remote and automatic entry of the flight mission and retargeting; individual targeting of warheads of separable warheads at individual targets and cover (protection) of warheads with

[28] Malynovskyi 2004, p. 108.
[29] Vakhno N.I. 2014, p. 278.

imaginary targets; maintaining performance and accurate targeting in the case of a seismic impact on the launch position in the event of nuclear explosions in the launch area.[30]


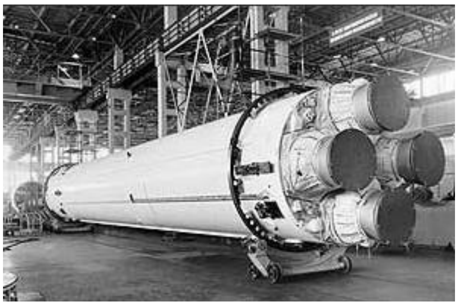

Fig. 13. UR-100NU (15A35) IBM. Source: Vakhno 2014, p. 210.

V. H. Serheiev's unique attitude helped him direct the team's creativity towards the possibility of using combat missiles which ended their service life for the needs of the national economy. For this purpose, control systems for launch vehicles and artificial Earth satellites were developed, in particular a short-range R-12 rocket was used to create a launch vehicle that launched ca. 800 artificial Earth satellites of the "Kosmos" and "Interkosmos" series for various purposes.

Under the leadership of chief designer V. H. Serheiev, experts of the SDO-692 designed and manufactured the latest control systems, including an on-board computer complex, for a number of spacecraft. These included the "Tselina" ("Tselina-O", "Tselina-D", "Tselina-R") and "Tselina-2" spacecraft, which were designed for overview and detailed radio observation of the Earth's surface.[31]

In the early 1970s, work was carried out to create a control system for the supply vehicle and the reentry vehicle of the "Almaz" multipurpose space system. A special department, part of the third programming department of the "Electropryborudobudovannia" Design Bureau, headed by B. M. Konoriev, developed a technology for the defect-free creation and testing of control programs, which included all stages of rocket and space systems development and their flight tests. It provided the ability to make quick necessary changes to the software at all stages of work, from pre-launch testing to in-orbit operations. For example, the computer control system of the "Almaz" rocket and space system supply ship autonomously executed the most complex flight program for two days without intervention from the Control Centre, consisting of the construction of orbital and gyroscopic coordinate systems, and three orbital transitions for search, convergence and, finally, docking with the "Saliut" station.[32]

For the first time in the USSR, an on-board computer was used in the control system, which provided the spacecraft with the ability to automatically approach and dock with another object. The automatic docking of the resupply vehicle with the "Saliut-6" and "Saliut-7" space stations was a complete triumph of the ideas initiated by V. H. Serheiev.[33] In the following years, the experience of supply transport vehicles was widely used in the development of a whole series of spacecraft for various purposes: a module transport vehicle for approaching and docking with the "Saliut" station and the target orbital modules "Krystal", "Spektr", "Kvant", "Kvant-2", "Pryroda" that became a part of the "Myr" station. For these modules, a multi-level majoring system was created that maintains performance in the presence of 10–20 faults. Its trouble-free operation in orbit for more than 10 years confirmed the correctness of the technical solutions initiated by V. N. Serheiev. In his memoirs, cosmonaut Oleksandr

[30] Zavalishin 1997, p. 73.
[31] Voitiuk, Tverytnykova, Gutnyk, Kuzmenko, Kolisnyk 2022, p. 682.
[32] Gorbulin, Vasilenko, Mitrakhov 2014, p. 94.
[33] Shudrik 2014, p. 170.

Lazutkin wrote that even in the last seconds of its existence, “Myr” station worked in accordance with the set algorithm, without failures and errors. And the main contribution to the development of high-precision equipment belonged to the scientific team of the “Elektroprylad” bureau and chief designer V. H. Serheiev.[34] The scientist also led the development of the control system for the “Zoria” module of the International Space Station “Alfa”.[35]

5. Scientific and technical school for the development of control systems of rocket and space engineering

V. H. Serheiev’s effective scientific, engineering and analytical work, as well as his leadership skills contributed to the creation of an important scientific and technical school for the development of rocket and space technology control systems at the enterprise. And certainly, one of the main achievements of Academician V. H. Serheiev is the creation of a training system for scientific and engineering personnel, which contributed to the formation of a community of chief designers of control systems. They were: A. I. Perederiy — for the R-36M intercontinental ballistic missile; V. A. Uralov — for the UR-100N (15A30), UR-100NU, R-36 UTTH and R-36M2; A. S. Gonchar — for the “Energia” launch vehicle; and A. I. Kryvonosov — for on-board computers. All of them were highly qualified specialists in the development of the most complex equipment, working under the leadership of V. H. Serheiev.[36]

Recognizing the need to train scientific personnel in specialized fields, in 1962 V. H. Serheiev organized a postgraduate course for young scientists at the enterprise. Ten people were enrolled each year in the postgraduate program. Theses were prepared in the following specialties: “Special-purpose systems for information processing and control”, “Elements of computer engineering and control systems”, “Mathematical support of computers and systems”.[37]

In the mid-1960s, on the initiative of V. H. Serheiev and with the support of Professor A. V. Dabagian of the Kharkiv Polytechnic Institute, the specialty “Flight Dynamics and Motion Control of Rockets and Spacecraft” was opened at the Faculty of Engineering and Physics of the Kharkiv Polytechnic Institute. At the same time, an agreement was concluded on the targeted training of mechanical engineers for the “Electropryborudobudovannia” Design Bureau. Graduates of this specialty are still involved in the creation of unique control systems for aerospace facilities, nuclear power facilities, and turbine construction. The group of the department’s graduates includes such professors as Y. Y. Aleksandrov, Y. M. Andreiev, M. D. Godlevskyi, V. Y. Zaruba, O. S. Kutsenko, and V. B. Uspenskyi, who are now educating future research engineers at NTU “KhPI”.[38]

The improvement of the management principles of rocket and space engineering objects, for which the enterprise developed control systems, was carried out under the leadership of V. H. Serheiev using the most modern scientific and technical ideas, methods and equipment. One of the enterprise’s activities was the productive cooperation with higher education institutions, such as Kharkiv Aviation Institute (Department of Aircraft Control Systems), Kharkiv Polytechnic Institute (Department of Automatic Motion Control, now Control Systems and Processes), Kharkiv Institute of Radio Electronics, and Kharkiv State University. As a result, a unique consolidation was created, recognized far beyond the borders of Ukraine — a scientific school of dynamics and managers who provided solutions to the problems

[34] *ibid.*, p. 171.
[35] Chumachenko, Kuznetsov 2014, p. 7.
[36] Vakhno 2014, p. 330.
[37] Vakhno 2014, p. 270.
[38] Gorelova, Larin 2013, p. 32.

of controlling objects with complex dynamic schemes. In 1986, "Electroprylad" employed 86 candidates and 5 doctors of technical sciences.

Under the leadership of V. H. Serheiev and with his direct participation, more than 500 scientific papers were prepared and 7 inventions were developed, most of which were implemented in various rocket and space complexes. In 1984, the enterprise was visited by the President of the USSR Academy of Sciences, Academician A. P. Aleksandrov, and the President of the Ukrainian SSR Academy of Sciences, Academician B. Y. Paton (Fig. 14).[39]

Fig. 14. V. H. Serheiev during the meeting at the "Hartron" enterprise, 1984.
(first row, from left to right: A. P. Aleksandrov, V. H. Serheiev, B. Y. Paton, V. P. Mysnychenko, A. P. Zubov; second row: G. A. Borzenko, V. I. Kovalev, A. I. Kryvonosov, V. A. Uralov, G. I. Liashchev, Y. E. Aizenberg, A. I. Gurzhiev, A. S. Gonchar, Y. N. Sverdlov). Source: Gorbulin, Vasilenko, Mitrakhov 2014, p. 94.

The above facts suggest that under the leadership of V. H. Serheiev, one of the leading research and development schools of the Ukrainian rocket and space industry, which is globally renowned, was created at the "Elektropryladobudovannia" Design Bureau (now JSC "Hartron"). Today, the specialists of this school continue to successfully develop and manufacture unique control systems for rockets and spacecraft, the quality of which meets the highest standards.

Several generations of scientists represent the scientific school of V. H. Serheiev, which has developed into new scientific fields and schools. First of all, these are such scientists as A. S. Gonchar, G. A. Borzenko, G. I. Lyaschev, V. N. Romanenko, B. M. Gavranek, B. M. Konorev, G. I. Lyaschev, V. N. Romanenko, A. I. Krivonosov, A. I. Perederiy, V. O. Uralov, V. K. Kopyl, V. O. Batayev, O. V. Bek, I. M. Bondarenko, Y. M. Borushko, M. I. Vakhno, I. V. Velbitsky, Y. M. Zlatkin, N. S. Isakov, A. N. Kalnoguz, V. P. Kamenev, O. F. Kirichenko, V. I. Kotovych, S. S. Koruma, V. I. Kotovych, O. O. Luchenko, E. M. Potapenko, V. P. Rzhemovsky, V. G. Simagin, E. Y. Sinelnikov, V. D. Stadnyk, V. S. Stolitnyi, V. G. Sukhorebryi, V. I. Chumachenko, V. T. Shcherbachenko, and others.

V. H. Serheiev died on April 29, 2009. In the same year, a memorial plaque was installed on the house number 36/38 (4th entrance, 7th floor) in Sumska Street, where the scientist lived (Fig. 15).

[39] Gorbulin, Vasilenko, Mitrakhov 2014, p. 95.

Fig. 15. V.H. Serheiev's memorial plaque in Kharkiv, Ukraine
Source: Vakhno 2014, p. 434.

6. Conclusion

The figure of Academician of the National Academy of Sciences of Ukraine V. H. Serheiev undoubtedly belongs to the pleiad of the country's leading scientists. For his outstanding achievements in the development of rocket and space technology, V. H. Serheiev was awarded state awards and was the winner of four State Awards. He created the latest advanced technologies and defined strategies for their implementation in various industries and science. The control systems developed under his leadership were implemented in the international projects of "Dnipro", "Rokit" and "Strila" launch vehicles for launching commercial vehicles into orbit. He was the head and for a long time the chief designer of the enterprise, which was known in different years as Special Design Office No. 692, "Elektropryladobudovannia" Design Bureau, Research and Production Enterprise "Elektroprylad" and Joint Stock Company "Hartron".

In the control system of the R-36M (15A14) missile, the innovative introduction of an on-board computer developed by the "Elektropryladobudovannia" Design Bureau was a revolutionary step that led to a significant increase in accuracy, speed and reliability, marking a qualitative leap in the development of missile technology. The scientific team of this enterprise made an innovative breakthrough in the development of control systems for rocket and space technology by developing and implementing on-board digital computers, in particular the M6M. This invention was the first in the world to ensure the operability of the control system of the SS-18 Satan intercontinental ballistic missile, as well as the successful launch and flight of the world's most powerful Energia launch vehicle.

V. H. Serheiev led the company for 26 years and thanks to his perseverance, organizational skills, and scientific talent, the achievements of Ukrainian rocketry specialists have gained worldwide recognition. After the terrible disaster of 1960, when the rocket industry was left without leading scientists and managers, in less than a year he managed to establish the enterprise, define its organizational and structural component, clarify the tasks of each department, renew scientific ties, and establish a scientific school. His initiatives in the use of regulatory documents, in particular ISO 9000 quality management systems, development of the elemental base for control systems for various types of rockets and spacecraft, creation of a methodological and theoretical basis for solving problems of designing high-precision control systems were of great significance.

As part of this organization, he created a unique research team — the research and development school of control systems for rocket and space technology dynamics and design of rocket and space objects, which has become world-famous for its achievements. The achievements of V. H. Serheiev and of the school in the implementation of national space programs have strengthened Ukraine's position as a high-tech state in the global scientific community. His work is an example of how a scientific approach to the design of control systems can influence technological progress and the development of the rocket and space industry. The scientific heritage of V. H. Serheiev inspires modern specialists to continue and develop the traditions of Ukrainian space science and technology. The high-tech technologies and highly efficient control systems for rocket and space complexes initiated by V. H. Serheiev are the national heritage and pride of Ukraine.

V. H. Serheiev paid a lot of attention to people. On his initiative and with his support, a district named after the founder of aerodynamics, M. E. Zhukovskyi, was created in Kharkiv for employees of JSC "Hartron". The Zhukovskyi neighborhood was located near the enterprise and had a well-developed infrastructure: kindergartens, schools, shops, a swimming pool and a complex of residential buildings.

BIBLIOGRAPHY

ARCHIVE SOURCES

Archive of the Presidium of the National Academy of Sciences of Ukraine (Archive of the Presidium of the NAS of Ukraine), f. 251, case 354: Personal file of Sergeev Vladimir Grigorievich, 56 p.

Archive of the Central State Archive of Public Associations and Ukrainians (Archives of the CDAGO), f. 1, desc. 24, case 711: Information to the Central Committee of the Communist Party of the Soviet Union; reports and certificates from the defense industry department of the Central Committee of the Communist Party of Ukraine; letters to regional party committees; information from regional party committees and other organizations on defense industry issues, 237 p.

Archive of the museum of the Joint Stock Company "Hartron" (hereafter AM of the JSC "Hartron"). *Photos from the history of the rocket and space industry.* cat. no. 15.

AM of the JSC "Hartron". *Reference from the personnel department.* cat. no. 21.

AM of the JSC "Hartron". *Personal records of the veteran of the Research and Production Enterprise "Hartron-Arkos" (hereafter RPE "Hartron-Arkos") Baranovsky G. A. First steps in Pomerki.* cat. no. 10.

AM of the JSC "Hartron". *Personal records of a veteran of the RPE "Hartron-Arkos" Borzenko G. A. Meetings with the Minister of General Mechanical Engineering - S. A. Afanasyev and the head of the enterprise - V. G. Sergeev.* cat. no. 10.

STUDIES

Aizenberg, Ya.E. 2010: *Rockets. Life. Fate. Memories.* Kharkiv. ISBN 978-966-8371-30-1.

Chumachenko, V.I., Kuznetsov, Yu.A. 2014: Chief Designer of Rocket and Spacecraft Control Systems. *Aviation and Space Engineering and Technology* 1, pp. 5–10.

Degtyarev, A.V. 2014: *Sixty years in rocket engineering and cosmonautics.* Dnepropetrovsk: ART-PRESS. ISBN 978-966-348-349-8 (Degtyarev, A.V.).

Degtyarev, A.V. 2014: *Yuzhnoye Design Bureau. People and rockets.* Dnepropetrovsk: SE "Yuzhnoye Design Bureau named after M.K. Yangel", 2014, 448 pp. ISBN 978-966-2374-47-6 (Photo album, Degtyarev, A.V.).

Gonchar, A. S. 2008: *The glory days of rocketry. Memories.* Kharkiv: Fact. ISBN 978-966-637-633-9.

Gorbulin, V.P., Vasilenko, B.E., Mitrakhov, N.A. 2014: Chief Designer of Control Systems of Rocket and Space Engineering (to the 100th anniversary of Academician V. H. Serheiev). Bulletin of the National Academy of Sciences of Ukraine 4, pp. 89-96.

Gorelova, S. A. 2009: History of the creation of the on-board computer and the "Electronic Start-up" inspection system at the Hartron Research and Production Enterprise. *Bulletin of NTU "KhPI"* 48, pp. 17–29.

URL: https://repository.kpi.kharkov.ua/server/api/core/bitstreams/9c34bb28-48d7-4d65-853b-ebc6e9646d65/content (accessed on: 9 January 2024).

Gorelova, S. A., Ivanov, L. V., Larin, A. A., Obolenskaya, L. A. 2014: Vladimir Grigorievich Sergeev - General Designer of Rocket and Space Control Systems. Dnipro Orbit 2014: [In:] *Abstracts of the IX scientific readings*, pp. 23–28. URL: https://repository.kpi.kharkov.ua/server/api/core/bitstreams/12e0f662-1878-40af-9bdb-d8eb7e73658e/content (accessed on: 9 January 2024).

Gorelova, S. A., Larin, A. A. 2013: Graduates of Kharkiv Polytechnic Institute in the rocket and space industry. Dnipro Orbit 2013: [In:] *Abstracts of the VIII scientific readings*, pp. 27–32. URL: https://repository.kpi.kharkov.ua/server/api/core/bitstreams/bcbcd1d9-a6b1-47a2-bfb7-9abe4b93ebae/content (accessed on: 9 January 2024).

Horbulin, V. P. 2021: *History of rocket and space science and engineering of Ukraine*. Kyiv: Fenix. ISBN 978-966-136-876-6 (Monograph, Horbulin, V. P.).

Horbulin, V.P., Koltachykhina, O.Iu., Khramov, Yu.O. 2014: Main periods and stages in the development of rocket and space technology of Ukraine. P.2. Development of Strategic Ballistic Missiles and Missile Systems (1957–1990). *Science and Science Studies* 2, pp. 76–103. URL: http://dspace.nbuv.gov.ua/bitstream/handle/123456789/86045/12-GorbulinNEW.pdf?sequence=1 (accessed on: 9 January 2024).

Larin, A.A.; Gutnyk, M.V.; Tkachenko, S.S.; Horielova, S.O. 2021: The contribution of Kharkiv enterprises to the rocket and space industry development. *Space Science and Technology* 4(131), pp. 83–90. DOI:10.15407/knit2021.04.083.

Malynovskyi, B.M. 2004: Known and unknown in the history of information technologies in Ukraine. Kyiv: Interlink. ISBN 966-8122-14-3.

Malinovskii, B.N. 1998: Essays on the history of computer science in Ukraine. Kyiv: Fenix. ISBN 5-87534-218-8.

Paton, B.Ie. 2015: *Outstanding designers of Ukraine*. Kyiv: NTUU "KPI". ISBN 978-966-622-435-7 ("Outstanding designers of Ukraine", vol. 7, Paton, B.Ie.).

Shudrik, I. O. 2014: *Works of Memoir specialists*. Kharkiv: Kursor. (Anniversary collection of scientific articles on memoirs protection work, vol. 3, Shudrik, I.O.). URL: http://www.spadschina.kh.ua/assets/files/Vidannya/yuviley_chast%201.pdf (accessed on: 9 January 2024).

Tverytnykova, O. Ye., Belous, O.V. 2011: To the History of the Creation of the Scientific and Production Association "Hartron". *Issues of History of Science and Technology* 4(20), pp. 54–62.

Vakhno, N.I. 2014: Vladimir Grigoriev - Chief Designer of Control Systems. To the 100th anniversary of his birth: PJSC "Hartron". ISBN 978-617-696-197-0 (Vakhno, N.I.).

Voitiuk, O.; Tverytnykova, E.; Gutnyk, M.; Kuzmenko, N.; Kolisnyk, T. 2022: Development and Practical application of the Space System of Earth Observation in Ukraine (from experience of DO "Pivdenne" and JSC "Hartron"). [In:] *Proceedings of the 2022 IEEE 2nd Ukrainian Microwave Week, UkrMW* 2022, pp. 680–685. DOI:10.1109/UKRMW58013.2022.10037147.

Zavalishin, A.P. 1997: *Through Space and Time: Notes of a Veteran of the Baikonur Cosmodrome*. Dnepropetrovsk: Dniproknyha. ISBN 5-89975-085-5.

Zlatkin, Yu.M. 2006: *Scientific and Production Enterprise Hartron-Arcos. Chronicle of dates and events. 1959–2005*. Kharkov.

Zvonkova, G.L., Mitrakhov, M.O. 2014: V. H. Serheiev Scientific and Technical School of Academician of the National Academy of Sciences of Ukraine. *Science and Science Studies* 3, pp. 128–136.

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Fig. 1 Academician Volodymyr Hryhorovych Serheiev. Source: AM of the JSC "Hartron" cat. no. 15.

Fig. 2 V. H. Serheiev and M. K. Yangel. Source: Zlatkin 2006, p. 186.

Fig. 3 Stele-monument to the victims of the 24 October 1960 Baikonur disaster. Source: AM of the JSC “Hartron”. cat. no. 15.

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Fig. 6 General designers - V.F. Utkin, V.P. Glushko, M.O. Pilyugin, V. H. Serheiev, 1976. Source: A. Degtyarev 2014, p. 112.

Fig. 7 “Cyclone-2” LV, “Cyclone-3” LV, RT-20P IBM. Source: Vakhno 2014.

Fig. 8 The central processing unit of the M4M mainframe. Source: Vakhno 2014, p. 133.

Fig. 9 The launch of the R-36M UTTH (15A18) “Dnipro”. Source: Degtyarev 2014, p. 414.

Fig. 10 Chief Designer of Control Systems V.H. Sergeiev, Chief Designer of the “Voevoda” IBM, General Designer of “Yuzhnoye” Design Office V.F. Utkin, 1979. Source: A. Degtyarev 2014, p. 132

Fig. 11 The R-36M2 (15A18M) “Voevoda” IBM.

Fig. 12 The reusable transport space system “Energia-Buran”. Source: A. Degtyarev 2014, p. 176.

Fig. 13 UR-100NU (15A35) IBM. Source: Vakhno 2014, p. 210.

Fig. 14 V.H. Serheiev during the meeting at the “Hartron” enterprise, 1984. (first rank from left to right: A.P. Aleksandrov, V. H. Serheiev, B.Ye. Paton, V.P. Mysnychenko, A.P. Zubov; second rank: G.A. Borzenko, V.I. Kovalev, A.I. Kryvonosov, V.A. Uralov, G.I. Liashchev, Ya.E. Aizenberg, A.I. Gurzhiev, A.S. Gonchar, Y.N. Sverdlov). Source: Gorbulin, Vasilenko, Mitrakhov 2014, p. 94.

Fig. 15 Memorial plaque to V.H. Serheiev, Kharkiv, Ukraine Source: Vakhno 2014, p. 434.