History of Rocketry and Astronautics

Proceedings of the Forty-Fourth History Symposium of the International Academy of Astronautics

Prague, Czech Republic, 2010

Kerrie Dougherty, Volume Editor

Rick W. Sturdevant, Series Editor

AAS History Series, Volume 41

A Supplement to Advances in the Astronautical Sciences

IAA History Symposia, Volume 30

AAS Publications Office
P.O. Box 28130
San Diego, California 92198

Affiliated with the American Association for the Advancement of Science
Member of the International Astronautical Federation

First Printing 2014

ISSN 0730-3564

ISBN 978-0-87703-607-4 (Hard Cover Plus DVD)
ISBN 978-0-87703-608-1 (Soft Cover Plus DVD)

Published for the American Astronautical Society
by Univelt, Incorporated, P.O. Box 28130, San Diego, California 92198
Web Site: http://www.univelt.com

Printed and Bound in the U.S.A.

Chapter 9

Academician Vasiliy Sergeievich Budnik—One of the Founders of Space Rocketry in Ukraine*

Olexandr Novykov† and Stanislav Konyukhov†

Abstract

A Doctor of Engineering Science, Professor, Academician of the National Academy of Science of Ukraine, and Hero of Socialist Labor, Vasiliy Sergeievich Budnik (1913–2007) is one of the pioneers of space rocket engineering in the Soviet Union and Ukraine. One of the founders of the Yuzhnoye State Design Office (SDO) and the Yuzhny Machine-Building Plant, V. S. Budnik made a great personal contribution to the formation and development of the Dnepropetrovsk space rocket center and the space industry in Ukraine.

In 1945–1946, he was a member of a team of specialists headed by Chief Designer Sergei P. Korolev, who worked in Germany in order to study German rocket technology. From 1946, V. S. Budnik was a Deputy of S. P. Korolev, responsible for rocket design. He directly participated in the development and commissioning of the first Soviet ballistic missiles—R1, R2, and R5. For their serial production, a rocket plant was set up, in 1951, in Dnepropetrovsk, on the site of an automobile plant. Budnik was appointed as a Chief Designer of the plant, in accordance with Korolev's proposal. A team formed and headed by V. S. Budnik developed the R-12 (SS-4) ballistic missile, based on new princi-

* Presented at the Forty-Fourth History Symposium of the International Academy of Astronautics, 27 September – 1 October, 2010, Prague, Czech Republic. Paper IAC-10-E4.2.06.

† Yuzhnoye State Design Office, Dnepropetrovsk, Ukraine.

ples of high-temperature propellants and an autonomous control system: they became the basis of the Special Design Office OKB-586 (Yuzhnoye Design Office), established in 1954. Mikhail Kuzmich Yangel was appointed the Chief Designer of OKB-586, with Vasiliy Sergeyevich Budnik as his First Deputy.

Under the supervision, and with direct participation of V. S. Budnik, intermediate range ballistic missiles of a principally new type—the R-12 (SS-4) and R-14 (SS-5)—were developed, as well as the world's first heavy intercontinental ballistic missile, the R-16 (SS-7), the powerful ballistic missiles SS-9 and SS-18, and the Cosmos and Cosmos-2 space launch vehicles.

Figure 9–1: Vasiliy Sergeievich Budnik, (1913–2007), Academician of the National Academy of Science of Ukraine, Doctor of Engineering Science, Professor, Hero of Socialist Labor, and Lenin Prize Winner.

Introduction

Doctor of Engineering Science, Professor, Academician of the National Academy of Science of Ukraine, Hero of Socialist Labor and Lenin Prize winner, Vasiliy Sergeyevich Budnik (1913-2007) is one of the pioneers of space rocketry of the USSR and Ukraine. One of the founders of Yuzhnoye State Design Office and Yuzhnyy machine-building plant, V. Budnik made a considerable personal contribution to the formation and development of the Dnepropetrovsk space rocket center and to space rocketry in Ukraine.

Early Life

The biography of Vasiliy Budnik is typical for many people of his generation. He was born on 24 June 1913 in Ukraine, in the village of Semyonovka, Chernigov region, in the family of an agronomist. In 1932 he graduated from Minsk Architectural and Construction College and started to work in Moscow as a building technician and foreman. In 1934, Budnik followed his vocation and became a student of the Moscow Aviation Institute (MAI). After graduation from the MAI student's aviation club, Budnik flew gliders and planes, and then became an instructor pilot, teaching other students to fly.

Figure 9–2: Student days at the Moscow Aviation Institute.

Figure 9–3: Budnik learned to fly at the MAI student aviation club.

In 1940, Budnik obtained an honors degree and, being a mechanical engineer on aircraft armament, commenced work at the Aviation and Design Office, named after Sergei Ilyushin. IL-2 strafer aircraft, with powerful motors and reinforced armament, made a place for themselves in the history of World War II under the nicknames "flying tank" or "black death." Vasiliy Budnik's work on the armament of the IL-2 strafer, in 1941, earned him a Labor Valor Medal. In 1943, he was personally assigned by General Designer Ilyushin to fit missiles to the IL-2. From 1943, Budnik worked at the Scientific and Research Institute of Jet Aviation Number 1 (NII-1), formerly the Reactive Scientific–Research Institute (RNII), designing missile-armed strafers.

Investigating the V-2

When the war was over, the interest of the USSR* and the United States in the development of space rocketry and rocket missiles increased, and measures were taken to study the experience of the development of ballistic missiles in Germany. The experts had a clear understanding that, in the future, long-range ballistic missiles with nuclear weapons could become effective strategic weapons.

Figure 9–4: The group of specialists at the Nordhausen Institute, 1945.

* Union of Soviet Socialist Republics, or Soviet Union.

The USSR sent a team of experts to Germany, to enable it to become acquainted with the design of the V-2 missile, study the technology of V-2 manufacture, restore drawings of the missile, and collect structural elements. The special team included eminent specialists, who later became leading scientists, designers, organizers, and made possible the rapid national development of space rocketry: M. Tikhonravov, Y. Pobedonostsev, S. Korolev, V. Glushko, Y. Moszhorin, N. Pilyugin, V. Kuznetsov, V. Barmin, and many others. Therefore, in the occupation zone of the Soviet Union, the Nordhausen Institute was established, for the study of captured machinery. The special interdepartmental commission for the study of German rocketry included the young and perceptive designer, Vasiliy Budnik, and in 1945–1946 he worked in Germany.

The result of the team's work was the restoration of technical and design documentation on the missile, and the assembly of 19 missiles and ground equipment, identical to the originals. Thus, the work on long-range missiles in the Soviet Union and the United States started at the same level: mastering the German V-2 missile.

The Development of the USSR's First Missiles

On 13 May 1946, the decision of the Council of Ministers of the USSR, on the development of missile armament in the country, was signed personally by Josef Stalin. For the coordination of the development of projectiles with specific impulse, the principal Scientific-Research Institute Number 88 (NII-88, later TSNIIMash), was established. NII-88, based in the former Artillery Plant 88 at Podlipki, a town near Moscow, became a complex scientific, design, and production organization. After Stalin's directive, NII-88, under the guidance of S. Korolev, created a domestic copy of the V-2, named the R-1 missile. The R-1 was completely identical to the German V-2 missile, but it was manufactured using domestic drawings, materials, and technologies.

From 1946 to 1951, Vasiliy Budnik worked at the Central Scientific and Research Institute, as a Deputy of Chief Designer Korolev, on the design of operational missiles. He directly participated in the design, testing, and acceptance of missiles R-1, R-2, and R-5 for operational military service.

The first missile system using the R-1 missile had major drawbacks: poor targeting accuracy (±1.5 km at a 300 km range); complex and lengthy launch preparation; bulky launch processing equipment; the impossibility of keeping the vehicle fully fueled at the ready, due to the evaporation of the oxidizer (liquid oxygen). Despite the obvious drawbacks of the first operational missile, in 1950 it was approved for use for training the Army in missile operations and under war

conditions. After no more than a year, missile R-2 was designed by S. Korolev; it had none of the drawbacks of the R-1 and had considerably optimized performance characteristics: targeting range, warhead mass, and targeting accuracy.

Figure 9–5: Josef Stalin (left) and Sergei Korolev (right).

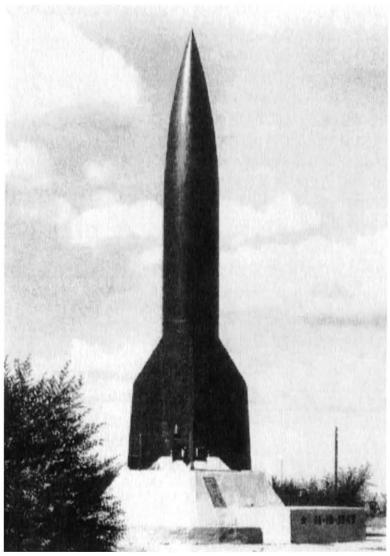


Figure 9–6: A monument to the first launch of the R-1 missile.

Figure 9–7: Dmitry Ustinov, Minister for the Armed Forces of the USSR.

After missile R-1 was accepted as a weapon, the problem of mass production of the operational missiles, in order to enhance the war potential of the state, emerged as a major issue. In Podlipki there was a pilot plant, but for mass production of missiles its capacities were not sufficient, and the possibilities for enlargement were limited. To select a proper plant for mass production of the first Soviet operational missiles, a government committee was established; it was headed by the Minister of Armed Forces, Dmitry Ustinov. Korolev proposed the inclusion of his Deputy for Rocket Design, Vasiliy Budnik, on this committee.

A Missile Plant at Dnepropetrovsk

Ustinov's idea was to choose a plant well-equipped, with future development potential, from any production sector, located in a remote regional area, and then change its production to the serial manufacture of rockets. In choosing a location for future rocket production, the committee visited a number of cities in the Ural region, in Siberia, and Ukraine. In the long run, it made its choice of a "newish" automobile plant in the city of Dnepropetrovsk, construction of which had started in mid-1944. In 1948, this plant had commenced manufacturing complete vehicles: motor trucks, such as the ZIS-150 of which it produced around 70,000 per year, and amphibious vehicles. Dnepropetrovsk had a number of positive features: before the war it had become a center for metallurgy and located nearby were the plants of raw material suppliers and high-capacity power facilities. The industrial center had a large number of qualified staff, and many higher educational establishments and colleges, where it was possible to train engineers and workers for the required specialties.

Stalin approved the decision of the Government Committee, despite the objections of the Minister of Motor Transport. Stalin said: "If we have rockets, we'll surely have trucks, and if we don't have rockets, there might not be any trucks either." The destiny of the Dnepropetrovsk plant was decided, and on 9 May 1951 came the decision of the Council of Ministers of the USSR, "On the transfer of the Dnepropetrovsk Automobile Plant to the Ministry of Arms." On 10 May, an order in this respect was issued by the Minister of Armed Forces, Dmitry Ustinov. The fact that rocket production appeared in Ukraine, and that later a space rocket industry was established there, reflects great credit on Vasiliy Budnik, who, being a member of the Government Committee, actively defended the idea of selection of the Dnepropetrovsk Automobile Plant for production of rockets. The choice of the Committee determined the destiny of the plant and of the city of Dnepropetrovsk. The little-known plant, over time, became well

known as the country's major space rocketry enterprise, the Yuzhny Machine-Building Plant, and Dnepropetrovsk became the space capital of Ukraine.

After the government decision, Vasiliy Budnik was assigned, with Korolev's approval, as the General Designer of the mass production rocket plant in Dnepropetrovsk. His major task was to organize the serial manufacture of the first Soviet combat missiles, designed by Chief Designer Korolev. Budnik prepared thoroughly to carry out this task, and in Moscow he selected a group of leading specialists on rockets from OKB-1, named after Sergei Korolev, and from engine OKB-456, named after Valery Glushko, to accompany him. Budnik made a list with a total of 25 people, from both design offices, all leading specialists on all systems of rockets and engines. In this list, he intentionally included, not only designers, but also planning and theoretical people, with the intention of implementing in-house development at the new plant. This caused strong objections from Korolev, who simply crossed all the planners and theorists off the submitted list. However, being a persistent and purposeful person, and having realized that specialist groups are all-important, Vasiliy Budnik carried his point with the highest levels of the Ministry. The group of specialists he selected became the core of the mass production design office of the plant, and later on, of the design office OKB-586 (Yuzhnoye SDO).

The mass production design office of the plant was established by the General Designer as a department equal to the other departments of the plant. The design office staff was composed of young specialists—graduates of the leading higher educational establishments of the country: MAI, Bauman Moscow State Technical University (MGTU), Leningrad Hydrometeorological Institute (LGMI), et cetera. The directive of the government imposed high rates of improvement in the mass production of the R-1 missile: 230 units in 1952, 700 units in 1953, and 2,500 units in 1954. The intense workload implemented at the plant was crowned with success. The first successful launch of an R-1 missile manufactured at the plant was carried out in November 1952.

Dnepropetrovsk's New Approach to Missile Design

When accepting his assignment as General Designer of the plant, Budnik had no doubts that, sooner or later, the mass production design office would pursue some independent creative activities. This was actually a need at the time. Missiles designed by Korolev used low-boiling propellant components (liquid oxygen and spirits), which was an essential disadvantage for missiles: as oxygen was constantly vaporizing, it was difficult to maintain constant operational readiness. The idea of creating a home-grown missile that would surpass in perform-

ance the missiles created by Korolev (the General Designer of ballistic missiles and a renowned monopolizer of space rocketry in the USSR) fired the imagination of the mass-production design office scientists.

Budnik entrusted a group of designers to begin development on a home-grown missile that would be attractive to the military and without the particular disadvantages of missiles designed by Korolev: a missile using high boiling-point, long-term storable propellant components, and an autonomous control system.

The prototype for the development of a home-grown missile was the latest version of the R-5, designed at Korolev's OKB-1; its conceptual design was issued in October 1951. While missiles R-1 and R-2 had as a prototype the V-2 missile, the R-5 was the first real Soviet ballistic missile. Compared to its predecessors, it had significant differences in configuration, design, and characteristics. The R-5 was a single-stage missile, with a monoblock head, that weighed 1,350 kg. Its fuel tanks were a thin-wall structure of aluminum alloy, supported by bulkheads. It had a combined control system, with autonomous control on range, and a radio system for the correction of lateral deviation, et cetera.

Budnik's young designers used the results of the scientific and research work of NII-88 to choose new design and engineering solutions. In the publication "Investigation of Options for Long-Range Missiles Using High-Boiling Oxidizer-Based Propellants," it was noted that the use of high-boiling oxidizers, though it reduces LPS specific thrust, provided a number of advantages, the major one of which was the possibility of long-term storage of a fuelled missile, with no loss of propellant through evaporation, essentially reducing the time needed for launch preparation.

The Origins of the R-12 Missile

The creation of a new missile using high-boiling aggressive propellant components (nitric acid and kerosene) required solutions to a number of questions relating to materials: it was necessary to ensure their stability against the aggressive environment of the propellants, during long-term storage in missile tanks, et cetera. It was also necessary to find design and engineering solutions that would enable better thrust and performance characteristics than those of the R-5 missile. Korolev considered the use of high-boiling components for long-range ballistic missiles inexpedient and without potential. Thus Budnik and his staff were at odds with their Alma Mater OKB-1 and Korolev, who was the only indisputable authority in the space rocketry field.

Having outlined the configuration of the missile and a circle of subcontractors, the mass production design office sent its proposals to the Ministry of Defense and found support there. At once, Korolev and his deputies, V. Mishin and K. Bushuyev, strongly objected to the design studies of the mass production design office and set out to prove to various state agencies the inexpediency of developing missiles with high-boiling point propellants. However, the anticipated advantages of the Dnepropetrovsk design were of such importance to the military that, on 13 February 1953, a Government Directive was issued, which stated that the mass production design office was entrusted with making the conceptual design for domestic missile R-12.

The mass production design office had a heavy workload with the mass production of missiles and had no design department: therefore it was difficult to issue a valid and qualitative conceptual design for the R-12 missile. The realization of this new missile, in the long run, was achieved mainly due to the unending enthusiasm of the young designers in the mass production design office. This was great victory for the staff, guided by Budnik.

The Creation of the Yuzhnoye Special Design Office

By resolution of the Communist Party of the Soviet Union (CPSU) Central Committee and the Council of Ministers of the USSR, in 1954, the mass production design office of the plant was transformed into Special Design Office #586 (Yuzhnoye SDO). The main task of the new design office was to develop combat ballistic missiles using long-term storable (high-boiling) propellants. This was a new chapter in the history of national space rocketry development. The country gained its second, after Korolev's OKB-1, design and development company for the creation of combat missiles, which offered a new paradigm with more potential for armaments: this would allow for future reductions in cost, simplification of production and rocket-space complexes, and enhanced operational readiness. It marked the end of Korolev's monopoly of space rocketry, and also the beginning of an open struggle between the two technologies of combat missilery.

On 9 June 1954, by the Resolution of the Minister of Defense of the USSR, Mikhail K. Yangel was assigned as General Designer and Head of OKB-586. Vasiliy Budnik became his First Deputy. By this time, Budnik had already formed the young, creative team at Yuzhnoye SDO, and developed the conceptual design of the R-12 missile. The immense personal input of Budnik to this revolutionary project was that, under his guidance, the conceptual design of a basically new strategic missile—using high-boiling point propellant components

and with an autonomous control system—was created, contrary to existing precepts and in spite of the strong objections of Korolev.

Figure 9–8: Mikhail Yangel (left) and Vasiliy Budnik (right), General Designer and First Deputy of OKB-586, the Yuzhnoye Special Design Office.

The Success of the R-12 Missile

After the appointment of M. Yangel, design activities progressed further. Yangel proposed to finalize the already developed conceptual design of the R-12 missile, with two considerable changes: to enhance the range of the missile up to 2,000 km and to enable installation of a warhead with a nuclear charge. In March 1955, the concept design of missile R-12 and a mockup were demonstrated to the customer. By its resolutions, the government then gave the green light for full-scale development. On 22 June 1957, the first successful launch of the R-12 missile was carried out. This was the great victory for the young Special Design Office.

Due to its comparative simplicity, reliability, and high operational readiness, the R-12 missile became the most produced intermediate-range missile accepted for deployment. The development of strategic missile R-12, with a nuclear warhead and range of 2,000 km, capable of being fueled and ready for launch for a whole month, and with considerable cost efficiency and simplicity of manufacture, was such a breakthrough in the field of strategic armament, that for this development the young OKB-586 and the manufacturing plant were honored with

the highest award—the Order of Lenin. General Designer Yangel and his First Deputy, V. Budnik, were awarded the honor titles of Hero of Socialist Labor.

Due to their comparative simplicity in operation, the new strategic missiles designed by the Yuzhnoye SDO had the potential for rapid and wide deployment with the Army. With these new capabilities, the new military doctrine of the USSR was established. The key role in the military strategy of the country was given to ballistic missiles, which became the decisive impact factor in combat. In 1959, a new branch of the armed forces of the USSR was created: the strategic missile forces. The first strategic missile, R-12, beat all records for length of time in service (more than 30 years). It was only retired from active service in 1989, during the liquidation of intermediate-range missiles as a class, following the treaty between the USSR and the United States.

The Development of the R-14 and R-16 Missiles

Under the guidance, and with the direct participation, of Vasiliy Budnik, strategic missiles R-14 and R-16 were designed and put to service. The R-14 missile was a further development and enhancement of the R-12 missile: it demonstrated the maximum capabilities of a single-stage rocket using high-boiling point propellant components, with a range of ~4,500 km. It was put into service in 1961. The R-16 missile was basically a new two-stage intercontinental missile, with a range of more than 13,000 km, put into service in 1962.

Figure 9–9: The R-14 (8k-65) missile, also known as the SS-5 Skean.

The R-14 and R-16 missiles were developed in competition with Korolev's OKB-1. The R-9A two-stage intercontinental ballistic missile (ICBM), using low-boiling point propellants (liquid oxygen and kerosene) and designed by OKB-1, was an outstanding missile for its time, due to its design perfection. Taking into account the irreconcilable attitude of OKB-1 to the development of ICBMs using high-boiling point propellants, the government decided to establish an expert scientific review of the conceptual design of the R-16 developed by the Yuzhnoye SDO. This expert committee was headed by academician Mistislav Keldysh. Counterarguments were presented by Korolev's Deputies, V. Mishin and K. Bushuyev, while the engineering solutions of Yuzhnoye SDO were defended by the group of planners headed by V. Budnik.

Eventually, the expert committee came to the conclusion that it was possible to develop the R-16 ICBM with the proposed characteristics. Although Korolev's ICBM R-9A was later put into service by a government resolution, this was the last combat missile designed by OKB-1, as military experts considered the decision on the development of the R-9A to be erroneous. Yuzhnoye SDO would take the key role in the country in the development of combat missile systems, and this fact enabled Korolev to concentrate fully on pure space issues, allowing the Soviet Union to become a leading world space power. Yuzhnoye SDO also paid considerable attention to solving space issues. Based on its operational R-12 and R-14 missiles, under the guidance and direct participation of Vasiliy Budnik, the Cosmos and Cosmos-2 launch vehicles were developed.

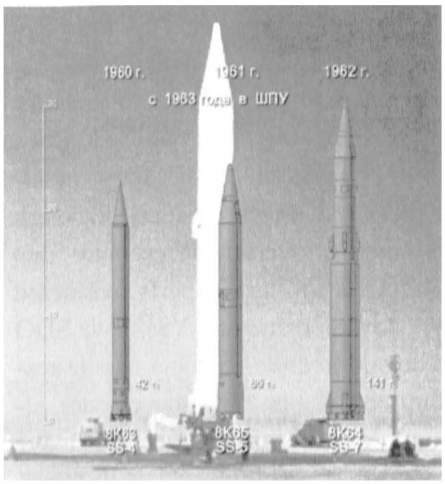
Budnik's Legacy

Vasiliy Budnik made an immense personal contribution to the formation and development of Yuzhnoye SDO as a powerful scientific and design enterprise. In succession, Yuzhnoye SDO created four generations of combat strategic systems that had no analogs in the world, and that became the basis of the strategic missile forces in the Soviet Union: it developed seven types of launch vehicles, 40 types of liquid and solid propellant rocket engines, and more than 400 spacecraft of home-grown design.

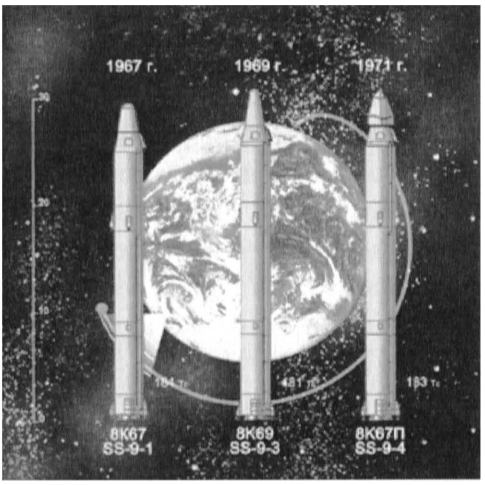
For his work in the development and bringing into service unique examples of space rocketry, Vasiliy Budnik was honored with many government awards and titles: the Order of the Red Banner in 1956 and 1976, the Order of Lenin in 1959 and 1961, Hero of Socialist Labor (1959), and the Lenin Prize (1960).

Budnik always attached importance to the scientific background of work, engineering, and scientific personnel training. In 1954, he directly took part in

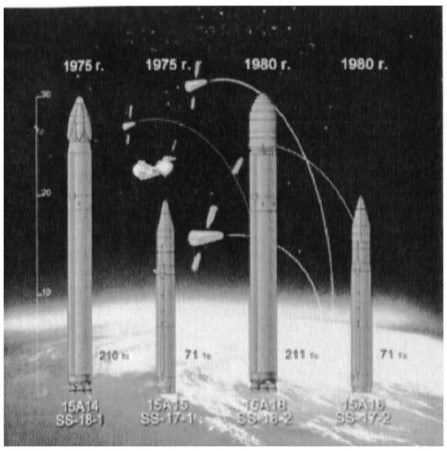
the formation of the physical and technical facility at the Dnepropetrovsk University, where specialists in space rocketry were trained; during the period of its existence, more than 20,000 specialists were trained at this facility. In 1962, Budnik became Professor at this university. In 1964, he was elected a Corresponding Member, and, in 1967, an Academician of the Academy of Science of Ukraine.



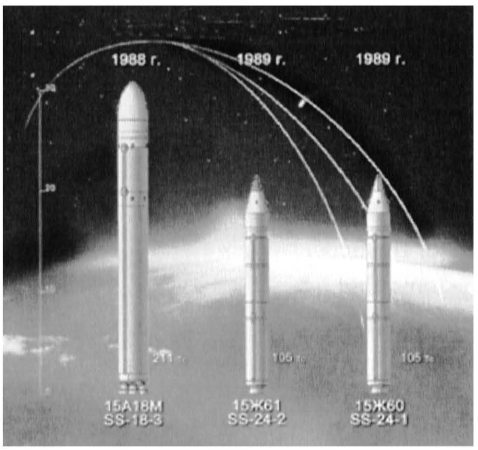
First generation (1960–1963)



Second generation (1967–1971)



Third generation (1975–1980)



Fourth generation (1986–1989)

Figure 9–10: The four generations of combat missiles developed by the Yuzhnoye SDO.

From 1972, Budnik worked at the Institute of Engineering Mechanics at the National Academy of Sciences of Ukraine, where he supervised investiga-

tions into the optimum design of rocket and space systems. He prepared a number of Candidates and Doctors of Science. In 1983, he was honored with the title Honored Science Worker of the Ukrainian Soviet Socialist Republic (SSR). Budnik was one of the founders of the Dnepropetrovsk scientific rocket construction school.

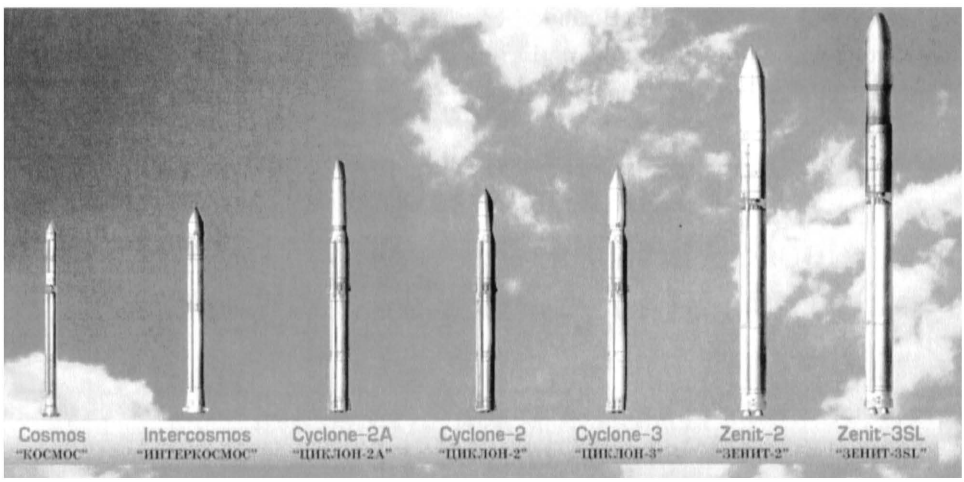


Figure 9–11: The family of space launch vehicles developed in Dnepropetrovsk.

Figure 9–12: Vasily Budnik, Academician and distinguished rocket developer, in his later years.

Conclusion

Vasiliy Budnik was always distinguished for his indefatigable energy and purposefulness, exactingness, talent for organization, thoroughness, systematic approach to work and persistence in reaching goals, wide scientific and engineering scope, boldness in taking decisions, and skills to put decisions into effect. All these personal traits helped Budnik become a pioneer in the development of unique rocket and space systems and to play a historic role in the creation of the Dnepropetrovsk rocket and space center and space rocketry in Ukraine.