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Chapter 25

V. S. Budnik Is the Person Who Laid the Groundwork for Design Bureau "Yujnoe"*

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Abstract

This chapter describes a son of the Ukrainian people, his elapsed path from a family of agriculturists up to the first deputy and the outstanding designers of space technology (Sergei P. Korolev, Mikhail K. Yangel, and Vladimir F. Utkin), to a distinguished designer of rockets and to a scientist of space engineering. The hard destiny of Yu. A. Pobedonoszev, S. P. Korolev's disciple, is demonstrated as a man of clear head, vast designer talent, personal charm, courageous and principled, a defender of truth, irrespective of a conjuncture. The chapter analyzes the designer and scientific elaborations and participation of Vasiliy Sergeevich Budnik, demonstrates his designing talent and contribution to the world achievements of space engineering. Unknown to the general public are facts of the unique biography of Budnik, working during 60 years in missilery, and are presented within the background of a general history of missilery development in the Soviet Union. This chapter fills a gap in space history, hushed up undeservedly, regarding the greatest scientist of space-rocket engineering.

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Introduction

The name of the outstanding designer of the most parts of Soviet rockets and of the scientist of space-rocket engineering, V. S. Budnik, is poorly known owing to privacy and his second roles—formal, instead of actual. The world knows the distinguished Soviet general designers, S. Korolev, M. Yangel, and V. Utkin, but few people know that V. S. Budnik was a first deputy over them. Moreover, he laid the groundwork for Design Bureau (DB) Yugmach, and he designed a rocket, which subsequently became the first Dnepropetrovsk rocket and the stock of the whole breed of battle guided-missile systems with an offline system of control before the arrival in Dnepropetrovsk of M. Yangel. Budnik is a living history of Soviet rocket manufacturing.

Ukraine—Byelorussia—Russia

The famous son of the Ukrainian people Vasiliy Sergeevich Budnik was born on 24 June 1913 in a village, Semenivka, of the Chernigov area into a family of agriculturists. He received schooling and mean professional education in Byelorussia, in Minsk, where he finished at the architectural-building technical school with a professional specialization in "concrete designs" (1932) after seven years of school and general educational college (1928). He began a length of service as a technician for a builder in Minsk, and he later worked as a superintendent in Moscow.

Military Aviation Was in the Beginning

In 1934 Budnik decided to build airplanes and entered the best higher educational institution in the Moscow air institute (MAI) on an "arms of airplanes" professional track. In the institute he got to know Mikhail Yangel, who was secretary of the Komsomol organization of the institute. Budnik's abilities and inquisitiveness not only helped him to achieve "excellent" in study, but to finish sailplane school in the beginning and also to finish flying school, then to fly 1,000 hours on sporting airplanes and to be the pilot—instructor even. But there were mainly his studies. The peculiarity of the teaching activity in higher schools was broad, engaging with activity of the largest designers and aviation scientists at that time. Therefore Budnik considered as his first design teachers the talented aircraft designer P. D. Grouchin, to whose lectures he not only listened but with whose group of designers he also worked; also the father of a helicopter construction B. N. Yuriev; and the distinguished designer of military and civil airplanes Sergey V. Ilyuchin. Ilyuchin "finished" the young designer in his DB after the termination of MAI in 1940.

A distinctive feature of almost all first designers of Soviet rockets was that they began their activity from aircraft, and then they passed into missilery. The requirements of airplanes always were tighter than those of unmanned flight vehicles for understandable reasons. This might explain the greater reliability of Soviet missilery compared to American.[1] For four years of activity, beginning as an engineer–designer and then as a group chief on arms of airplanes, Budnik participated in reequipping the IL-2 attack airplane, having established two types of rocket missiles or air cannons. This transformed the IL-2 attack airplane into "the flying tank" that alarmed the Germans in World War II. They called it the "Black Death." Participation in reequipment of the IL-2 attack airplane by the group with Budnik played an important part in Soviet attack aviation dominating the sky.

This activity not only showed the special talents of the young designer, not only submitted him to a wide experience in military aircraft construction, but also called an interest to rocket missiles. Therefore, when Budnik was invited to work in the research institute No. 1 (earlier RNII), where rocket missiles were designed, he agreed with this proposal.

Early Career

The Sources

Sixty years back, the first work of new "the rocket designer" V. Budnik was a project involving an attack airplane with a rocket engine, completely by armed rockets. Budnik prolonged his learning through new work in the research institute No. 1, and one of the pioneers of the missilery, Professor Yu. A. Pobedonoszev, took up the post of his teacher. Unfortunately, the work of S. P. Korolev (as the chief engineer) and Valentin P. Glushko at the institute before Budnik came took repressive action. His short stay in research institute No. 1, near the end of the war, further advanced Budnik's interest in a prospective trend of flight-vehicle development and prepared the grown-up engineer's scientific basis for participation in the creation of ballistic missiles. In 1944 this interest was boosted with appearance in the research institute No. 1 of fallen V-2 fragments. Analysis of bits and pieces from this German weapon allowed determination of only some of its characteristics, but it did not give a capability to restore drawings.[2] In 1945 the Soviet government realized the prospects for a new type of weapon and created a special commission for analysis of missilery in Germany. This commission was in Peenemünde two weeks after victory in World

War II. From the research institute No. 1, Pobedonoszev and Budnik participated in the commission.[3]

School V-2

The long-lived stay (20 months) in postwar Germany within the structure of this commission on analysis of the missilery trophy became a huge school for Budnik and his universities. Doubtless a benefit for the young rocketeer was the commission's professional creative atmosphere, into which other scientists also subsequently came: S. P. Korolev, V. P. Glushko, Mikhail S. Ryazanskiy, Viktor I. Kuznetsov, Mikhail K. Tikhonravov, Alexei M. Isaev, Vladimir P. Barmin, Nikolai A. Pilyugin, and Vasili P. Mishin. Already this enumeration of surnames (the majority of whom later became chief designers) shows how extensively and seriously the Soviet government considered the development of missilery, and how farsighted was government planning to guarantee personnel. In the literature, based partly on biased materials sometimes obtained from the Germans, the activity of this commission has been portrayed as groundless. Therefore this chapter shall use the testimony of a direct participant, Budnik.

What did our scientists see after arrival?

"In Peenemünde we have seen ruins of exploratory center and ground-level plant for production of rockets V-2, partially extant underground hangars with ready units for usage in rockets, the broken down launchers V-1 and V-2."[4]

What did Soviet specialists obtain?

First, it was possible to see German rockets firsthand and use them in practice to estimate generally the level reached. Its nature was not only psychological but, also, created reliance of work. The information received influenced the judgment of the chiefs, who selected the trend for military engineering development. In 1946 the Soviet government recognized that the V-2 work conducted in Germany had a serious basis and huge prospects.[5] Second, collected materials provided a basis for creation, under S. P. Korolev's management (with V. S. Budnik's participation as a member of the headquarters), of a reference book on German missilery. Thirteen volumes contain delineations of general layout views and tables of characteristics.[6] Third, 10 V-2 rockets were collected (truthfully, without electro and pneumo tests). These rockets were shipped to educational institutions and served as a visual aid for future specialists. Fourth, the majority of the documentation on tests and test stands (in particular for the engine, its automatics, and turbo-pump) was reconstructed. Moreover, flame tests of liquid-

propellant rocket engines (LPRE) were conducted. It was necessary to add to this definite successes on restoration of the documentation and know-how on a control system (CS) obtained by Boris E. Chertok together with Helmut Gröttrup, one of the chiefs of CS elaboration for a V-2 rocket.[7] Gröttrup was the one prime specialist, who had not gone over to the United States.[8] Personally for Budnik, the 20-month sojourn on a business trip in Germany raised him to his best level of understanding missilery at that time, allowed him to advance rapidly into the ranks of the forward-looking missilery designers, and gave padding to his personal contacts. He got to know Korolev in August 1945.

The Deputy Chief of S. P. Korolev on Construction of a Rocket (1947–1951)

The special design bureau (SDB) consisting of nine departments was organized for elaboration of liquid-propellant rockets in 1946 in Podlipki in the research institute No. 88. Department of ballistic liquid-propellant missiles No. 3, with S. P. Korolev as chief designer, had a task to recreate the V-2 as its first industrial task. Because of Korolev's talent, this department became central in the institute based on outcomes received. V. S. Budnik was assigned as Korolev's deputy chief "ON CONSTRUCTION" for the creation of long-range, controlled, liquid-propellant ballistic missiles in February 1947. This "five-year period" for Budnik was saturated by the first designer outcomes: preparation to launch the V-2 missile (first launches in October 1947), realization of the first military missile R-1 (first launch in autumn 1948), creation of the first geophysical rocket R-1A (first launch in May 1949), and creation of a combat missile R-2 (first launch in October 1950). Clearly, each year in SDB activity was marked by the launch of one of Korolev's new rockets. Certainly, the main burden of accountability for a design lay on the assistant, but the shoulder of such a "heavyweight" as Korolev was extremely powerful. Therefore, SDB-1 on elaboration of the ballistic missile (BM) with the chief and Chief Designer Korolev and his assistant, Budnik, was organized not incidentally on the foundation of department No. 3 in April 1950.[9]

A-4 (V-2)

Despite the fact that the A-4 was adopted as an armament of the German army, its reliability obviously did not satisfy the military, even though this rocket doubtlessly was "a considerable milestone in a history of all mankind, having far extended horizons and, as a matter of fact, having made a road to stars."[10] Therefore, the first problem for a main designer was to determine reasons for the A-4

launch failures, which resulted perhaps from design deficiencies. Credit must be given to Josef Stalin, who despite his seminary education, specified that the precise task of the first stage was to recreate an A-4 rocket without any changes.[11] Such an "overtake and surpass" approach was inherent in the Soviet Union, having shown efficiency and, furthermore, it was used in other countries (Japan, China).

What deficiencies were detected in the A-4?

These included a poor tail unit, one of which was shattered aloft from vibrations, a half finished control system, an imperfect engine, no separable warhead (WH), and not carrying fuel tanks.[12] Generally speaking, there were no special problems with eliminating these deficiencies. But, it was impossible also to change something at once in an A-4 design. Therefore, the technical policy of V. S. Budnik, chief of the designers, was cautious treatment of indispensable changes. For example, to ensure vibrations did not shatter the tail unit, designers only padded amplifying components. But for the main activity, which Budnik executed personally, there was a management of sorting by available units and rocket parts and A-4 assembly (creation of a serial "T"). Budnik, relying on designer experience, personally selected those units and aggregates based on what was available and which ones as a rule were untested and might have invisible (or visible) defects. Here Budnik's designer skills and engineering intuition of Budnik did not let him down. Thus 10 copies of the V-2, collected from different parts and aggregates, came to the DB's disposal without trial tests. There was one larger problem handicapping the realization of A-4 rocket firings. It was the absence of foreigners with experience launching the rockets. If the United States launched 66 V-2 rockets in five years—from 1946 until 1951—with the help of 400 German scientists and specialists, the Soviet Union, without using the Germans,[13] independently launched 11 rockets (five of which were successful) in October–November 1947.

P-1

Executing J. Stalin's personal task, expressed in modern language as "cloning" the A-4, S. P. Korolev was designing its Soviet version, the R-1, free from apparent deficiencies (distance of 270 kilometers, WH of 700 kilograms, lift-off weight of 13 tons).

What did the constructors do under the management of V. S. Budnik?

Despite the fact that the R-1 did not differ greatly from the A-4 at first sight, production of a rocket first required creation of the drawings. The drawings not only differed, they contained the manufacturing know-how of that should correspond to available capabilities.

And construction materials? The majority of them could not be repeated in the Soviet Union.[14] Such problems confronted the designers and R-2 and the subsequent R-5. And, all these problems were successfully solved under V. S. Budnik's management. The R-1 rocket was surrendered to the military in 1950 (index 8A11). During work on the R-1, this effective cooperation ensured the priority of the Soviet Union (and that was repeated by Europe through many years), when a separate DB was engaged in each direction. The SDB of V. P. Glushko was occupied with engines; the DBs of N. A. Pilyugin, V. I. Kuznetsov, and M. S. Ryazanski were occupied with control systems; and the DB of V. P. Barmin was focused on a ground-level complex. If independent solutions were "prohibited" in "copying" the A-4, they were encouraged in this one. Flight tests were accompanied by a streak of bad luck with numerous breakdowns, which spoke about the complexity of the problem even in this time of new engineering. Therefore, it became clear that the path to success was not leaping directly to a missile with a long range—3,000 kilometers—but step-by-step. In such a way the R-2 project appeared.

P-2

Korolev arrived at the idea, while in residence in Germany, that boosting the operating mode of the LPRE of an A-4 rocket by one-third increased the range more than two times (up to 600 kilometers).[15] To the moment of completing work on the R-1 it became clear that a rocket with a distance of 3,000 kilometers was required, and developing it was the real problem. But, true to his principles of escalating the distance step-by-step, Korolev realized the project of a rocket with a distance of 600 kilometers as identical to the R-1 with a warhead. The R-2 rocket already had new designer solutions: a separable WH, elimination of the carrying shell, a boosted engine, insertion of a new pneumatic and hydraulic scheme (PHS), and a changed control system (CS). The rocket successfully underwent tests and was introduced into the armament (under index 8G38).

The Resolution of a Problem of Series Production

The next step of V. S. Budnik's activity as S. P. Korolev's deputy chief for the construction of rockets was elaboration of rocket R-3. Its experimental model, R-3A (with a design distance of 935 kilometers, WH of 3 tons, and lift-off mass of 71 tons) had been moved to rocket R-5, whose preliminary design was reviewed in October 1951. The adoption of these rockets for armament spoke about military interest in a new kind of arms, but simultaneously raised the question about their series production, because a test plant in Podlipki lacked powers. The next missile (with a distance of more than 1,000 kilometers) should alter the course of the geopolitical situation involving opposition of two world systems, essentially with large-scale production of this missile. Therefore all-powerful L. P. Beriya, who sponsored a nuclear rocket industry, gave D. F. Ustinov of the military-industrial commission (MIC) a task to define which firm was necessary for redirecting on series production of rockets. A special commission was created for this purpose. Budnik was included in a structure of this commission.

To whom is Dnepropetrovsk indebted for discovery of its capability to become a world center of space technology?

The commission of D. Ustinov entrusted personally to V. S. Budnik to selection of the city and plant for series production. Among the candidate cities were Zlatoust, Miasss, Zaporozhye, Chelyabinsk, and Dnepropetrovsk. Also it is necessary to say that at the first stage Budnik was inclined toward Zlatoust. But at the last decisive stage, the commission gave attention to his proposal for Dnepropetrovsk. The Dnepropetrovsk car factory took up a huge area on the city's outskirts and had unlimited room for expansion; the city had a large number of high schools and metallurgical firms, was a large nodal railway station, which linked it with Donbass (coal), Kiev (authority and intellect), Harkov (science and personnel), and Krivoy Rog (ore). The river of Dnieper opened broad transport capabilities. Therefore, Budnik offered this city. The plant and design office (DB) was organized under the unlimited authority of D. F. Ustinov. A car factory, which already had manufactured some car-amphibians, was confiscated from the ministry of motor industry. Despite becoming the Dnepropetrovsk automobile plant (DAZ), letting out 50 lorries as DAZ-150, the Council of Ministers of the Soviet Union accepted the resolution about its transfer to the Ministry of Arms of the Soviet Union with conferment No. 586 (p. b. 186) on 9 May 1951.

The Chief Designer of Ballistic Missiles of Distant Action (1951–1954)

The Chief Designer, effective 6 July 1951, assigned V. S. Budnik to plant No. 586, which was reoriented toward the series production of long-range ballistic missiles and antiaircraft missiles.[16] Agreeing with this proposal, Budnik decided solidly that activity in Dnepropetrovsk not only would be serial, but also designing new rockets. Therefore he compiled a common list of 25 leading designers from the DBs of S. P. Korolev and V. P. Glushko. Despite S. P. Korolev's objections against the transfer of young designers, all of them moved to Dnepropetrovsk and, subsequently, almost all of them became chief designers, known to the whole world: Vyacheslav Kovtunenko, I. Ivanov, N. Gerasuta, N. Schniakin, M. Nazarov, L. Nazarova, P. Nikitin, M. Dvinin, and others. The presence of these specialists allowed Budnik to compound the same DB pattern as the SDB of Korolev. Success in resolving a similar problem depended on the professionalism of personnel, production, and financing. In such a new, little-known, and secret business as the creation of rockets, the key was instruction of personnel. And, Budnik organized for the DB the technical education of the designers under the theory of designing long-range missiles and on the manufacturability of designs. The training of specialists—rocketeers of average and higher education—was opened in a technical school and at university as work with an outlook. In 1952, J. Stalin signed the decree about discovery in Dnepropetrovsk State University (DSU) of physical and technical faculty, in which 10,000 world-class specialists were prepared. A service of Budnik was that he initiated sending to DSU the leading designers as teachers in special subjects. He personally read the lectures to students at the branch of designs and designing of rockets and participated in council activity on the defense of theses. Professors V. Kovtunenko, N. Gerasuta, M. Duplischev, and N. Schniakin became chiefs of chair at DSU. A large group of technologists and industrial workers from the experimental plant in Podlipki (N. Hohlov, G. Tumanov, and V. Medvedev) arrived simultaneously in Dnepropetrovsk.[17] Such operations gave splendid outcomes: the inhuman load on personnel "landing from Moscow" not only decreased, but it also showed world-class capabilities of achievement with respect to modern production in general.

Production of rockets was put on a solid factory basis, because the project of manufacturing a prototype, testing it, and manufacturing an experimental batch of missiles for flight tests were only preparatory to vast work on the issue of serial production. It required both improvement of working drawings and maintenance of manufacturability of each of as many as 10,000 parts,[18] decreas-

ing their price, intermediate tests of each part and each aggregate, and on a sampling basis of all rockets as a whole.

In June 1952 the first serial rocket, R-1, assembled on Yugmach was shipped. Its successful launching was made in November 1952.[19] Then the rockets R-2 and R-5M (the first strategic rocket from Korolev's DB) followed. The advanced production created in Dnepropetrovsk, unique not only in the Soviet Union but also in the world, allowed N. Khrushchev to state to the world a little later that Dnepropetrovsk turned out rockets "like sausages." These successes of the DB and plant at Dnepropetrovsk in the development of series production of guided-missile systems and their testing and surrender to the customer, along with the world's armaments race, army requirements, and forthcoming needs of a developing economy for near space, raised the question about insufficiency of one DB (Korolev). But Korolev's one rocket did not satisfy the main military requirement because of the necessity to have an oxygen plant on a launching area. From 1953, understanding all this, Budnik and the young enthusiasts who arrived with him began to conduct construction work on creating a simpler design, simpler to produce and exploit rocket, R-1M (8A12). Introduction of a new rocket control system allowed a twofold decrease in the dispersion ellipse, thereby improving the accuracy of fire. Subsequent launchings confirmed the best service performances of rocket R-1M.[20] Therefore, on 13 February 1953, a governmental decree was issued under military initiative for elaboration by the "Yugmach"plant of a preliminary design for a medium-range missile, R-12 (8A63), with high-boiling propellants.[21] Acquiring experience, not stopping on what it had reached and not harming series production, the DB of Budnik elaborated the preliminary design of a new ballistic missile capable of two times the distance of Korolev's R-5M in 1953. It became, by the beginning, a new trend in the development of missilery. With the first steps of the designer school, Budnik himself confirmed the originality of his design thought.

For support in originating a new direction, Budnik enlisted the cooperation of M. K. Yangel, chief engineer of the research institute No. 88, who he had known for a long time. Yangel came to Dnepropetrovsk several times at Budnik's invitation and, acquainted in detail with the DB and plant, was filled with the idea of a new trend and quickly became the adherent of Budnik. In 1954, based on Budnik's leadership, the DB was organized as an independent SDB with Chief M. Yangel and his chief deputy, V. Budnik.

About the Chief Designers in the Soviet Union

Such institutions as the general designers is the only Soviet invention that combined in one position the academic chief of scientific elaborations, the man-

ager, the party functionary (he was a member of the Central Committee of the communist party of the Soviet Union, or regional committee always), and member of parliament (People's Deputy) with a personality cult in the design office. Originally, missilery pioneers (Korolev and Glushko) were to become the chief designers. They had been by the real authorities on rocket technology. They had a lot of their own ideas, and they especially did not need the ideas of someone else. Afterward, the time of the former aircraft constructors (Budnik, Makeev, and Barmin) came, as they passed through the crucible of the rocket branch. The entrance, not of the specialists, but of good managers (Yangel and Tchelomey) reflected the worldwide tendency in control of design organizations in general. The appearance of chief designers who already had received rocket education, lifted this tendency onto a summit (Utkin, Semenov, and Nedaivoda).

Chief Deputy of M. K. Yangel (1954–1972)

As the Foundation of DB "Yugnoe" Was Laid

A certain digression has been made from the presentation of V. S. Budnik's life to show the conditions of his subsequent activity created in DB "Yugnoe." As mentioned above, Budnik was familiar with M. K. Yangel from the time of his education at MAI. In 15 years they had met already in Korolev's DB, where Yangel came as a department chief. In 1950 Yangel was acquainted with the NII-88 research on substantiating conversion of long-range rockets to higher-boiling propellants.[22] But with the rocket project already prepared in Dnepropetrovsk under Budnik's management, he was acquainted after business trips in the beginning of the 1950s, owing to Budnik's invitation at plant No. 586.

On 10 April 1954, by the Order of the Council of Ministers of the Soviet Union, the designer department of plant No. 586 was converted to Special Design Bureau No. 586 (SDB-586).[23] And, on 9 July 1954, M. K. Yangel was assigned as chief designer of SDB-586, with V. S. Budnik as chief deputy of the chief designer.[24] Further is simply this quote from I. Afanasiev: "Having taken for the basis the initial design of V. S. Budnik, M. K. Yangel could not and did not want to name the rocket as 'completely his own,' the elaboration of which he did not start. The advantages of the 'Dnepropetrovsk's child' appeared more clearly, since the project had been revised and offered BMMD with distance about 2,000 kilometers (more than 66 percent of the R-5M) and capability of carrying a more powerful WH."[25] The missile obtained the index of 8K63.[26]

Work with M. K. Yangel

The specificity of Soviet life was such that the Chief Designer was conducting a majority of on-duty time in Moscow, in closely connected enterprises. Therefore the present-day problems, the stale and creative life of the DB, were determined by his first deputy. Budnik, Yangel's chief deputy, was putting into practice those directions that main designer Yangel was thinking about in order to satisfy military requirements.[27] Therefore, the majority of all that was done in DB "Yugnoe" was due first of all to Budnik.

That was characteristic of Western managers. Altogether one can say that a unification of miscellaneous advantages of Yangel and Budnik (together with DB by the directors of L. Smirnov's and A. Makarov's plant) yielded the phenomenon of fast transformation of DBYu into the world's best rocket organization.

If Moscow had a lot of different DBs that did not allow paying special attention to rocket DBs, Ukraine's DBYu was one and, consequently, the republic's leaders encouraged its development, because the successes of DBYu also were the successes of the Ukrainian government in the face "of supreme Moscow authority." Therefore, the R-12 rocket was transformed into a space rocket for 400 DS (Dnepropetrovsk satellite) for the first international cooperation in the Soviet Union ("Interkosmos" satellite).

For a brief time M. K. Yangel, with his sober mind and his organizing ability, realized Budnik's plan to transform DBYu into a powerful design organization capable not only of competing with Korolev's SDB, but also of surpassing it. Therefore, after successfully entering into R-12 rocket operations, DBYu proposed a series of new elaborations of combat missiles with different distances, down from an intercontinental one. One of the few, but essential, errors in the creation of "Ukrainian missiles" became "fatal" for Ukraine after it obtained independence. It was waiving work on creation of liquid-fuel sustainers (the controlling engines with small thrust were engineered in DB-4 DBYu under the management of I. I. Ivanov[28]). Suppose that the main advantage of Yangel-Budnik activity in DBYu—compared with other chiefs of design organizations—was not narrow regionally, but a state approach to new activities. They were raising the problems, which one met the requirements both for military and political management of the country in conditions of cold-war opposition to the United States and for a government having financial problems unlike many metropolitan leaders, whose purpose was first of all "to snatch a large chunk." Therefore, all proposals at DBYu found comprehension almost always "in the upper strata." Following the Yangel-Budnik elaborations would reveal more correctly 8K65 as a single-stage rocket capable of 4,500 kilometers distance, and 8K64, a two-stage rocket capable of an intercontinental distance. These rockets were intended for

constant duty, in a charged condition, for high readiness to launch (as good as more costly American solid-propellant rockets). Then, an intercontinental combat missile, 8K67 (R-36), with a single-block using self-igniting propellants and three WHs for launch from a mine without the container, and the 15A14 and 15A15 rockets, with mortar start and divided WH (DWH), were designed. It must be said that the traditions of DBYu in aiding the creative design of combat rockets and an exploratory one surpassed the present by many years. Because V. F. Utkin was developing this backlog as the continuer of Yangel's military affairs, he was creating more rockets than all the remaining world together.[29]

Opposition

DBYu was existing all the time under a threat of closing, of the transfer of its problems to another DB. Possibly this was because of a return in capital of a lost "big chunk" of financing or as a consequence of other general designers' envy. Most likely it was the outcome of the known metropolitan superiority in relation to peripherals, with which people in Ukraine are very familiar. The history of the period of N. Khrushchev's government is known, when he commanded the transmittal of all new DBYu elaborations to Chief Designer V. N. Tchelomey. This competition with DBYu was connected personally to Khrushchev's family. The son of N. Khrushchev was working with Tchelomey, and the latter used this connection for bookings in strife with the competitors. The military also had the capability to give rocket assignments to different competitive organizations and to select what it considered a more eligible resolution. Certainly personal group interests had a role here. It was well-known that two powerful groupings were in the military-industrial commission (MIC). The first was headed by military minister Grechko (with minister of the rocket industry S. A. Afanasiev and "nuclear" minister Slavskiy), and the other was headed by D. Ustinov (with MIC chairman L. V. Smirnov). DBYu offered a rocket, R-36, and Tchelomey's DB offered its own. As the resolutions of DBYu were more progressive, N. Khrushchev commanded DBYu "to divide experience" with Tchelomey. About 20 men were ordered, or "borrowed," to impart to Tchelomey's DB the know-how of the Dnepropetrovsk engineers. Yangel, according to party discipline, dared not object to the Central Committee secretary's order but decided to lie down in the hospital.[30]

His chief deputy, Budnik, was missing at this time. All materials copied by the employees of Tchelomey's DB were entered in secret copybooks and awaited dispatch to Moscow. But, after Budnik returned and all was reported, he commanded that all entries be pulled from the copybooks and the empty copybooks be sent. After that a telephone call to Khrushchev took place. Budnik found a

courageous and unconventional way out of this less-than-ideal situation. Rocket R-36, made for a distance 16,000 kilometers, was prepared for launch. There was risk here because, as is well-known, first missile launches always result in malfunctions. Budnik selected the best copy of the rocket according to his known method and enormous experience, and he commanded its launch. The rocket showed startling outcomes for distance and closely-grouped fire. And it caused military minister Grechko to go to Khrushchev and offer not to close such a unique DB.

Fatal Defeat for Ukraine of Budnik

On meeting the academy of science immediately after Ukraine obtained independence, academician V. S. Budnik was warning about Ukraine's loss of capability in the main space-rocket area of activity DBYu and Yugmach, which was able "to decide the most severe and composite problems" and able "to play an essential role in development of a national economy of Ukraine and in strengthening its prestige among the states."[31] Unfortunately, Ukraine already had lost the main war direction, because all missilery had been returned to the Soviet Union. And, it was an outcome of Budnik's defeat in 1962. How was that? By the beginning of the 1960s, SDBYu elaborated on the basis of a rocket, R-14, the 65C3 booster project for orbital injection of large satellites. Simultaneously, in DB-3 DBYu research was conducted under V. M. Kovtunenko's management on the creation of three artificial satellites of Earth (two for communications satellites and one for meteorology) for the new booster.[32] Yangel feared (from one point of view groundless) that he could not manage this problem because of the overload of the DBYu and plant. "M. K. Yangel decides to transmit all available backlog this time on the booster and satellites to other organizations in second time."[33] It was strange. DBYu took these problems. Hardest elaborations were executed first. As this took place, any fear was absent, even considering the outlook on work at DBYu and Yugmach. When the time came to receive the bookings and "to cut the coupons," the fear appeared "not managed." Most likely the binding of financial assets in the country and the struggle for the bookings was beginning to show itself already. What is suspected is that the Siberian genesis of Yangel had no last role in granting to his peers such a "big chunk." In the beginning there was a game "in democracy." Yangel collected internal council with a question about forthcoming transfer of subjects. But here he met opposition from authorities of the missilery of Budnik and Kovtunenko.[34] "That do you do, Michail Kuzmich! The communication and meteorology are golden veins, you understand all that perfectly well!—be unable to constrain itself, gesticulating, the chief deputy V. S. Budnik shouted. Them we shall work so much, we shall

exist how many. It is work not only for DB, but also plant on all life! A weather and communication are always and they will be necessary permanently in all times!"

But Yangel, speaking to Budnik as the chief, transferred everything in Krasnoyarsk Rechetniov and in Moscow to Iosifian, throwing the game in democracy, despite specialists' opposition in council. Budnik's complaints were prophetic, and the indicated directions became really "golden" as a means of subsistence for many organizations in the world. After the loss of Ukrainian booster production[35] was visible, the activity in space communications, in monitoring weather, in remote sounding of Earth, for which Budnik fought 30 years back were now useful for Ukraine! This open opposition hurt Budnik.[36] Yangel took away from him all the rights and duties of a chief deputy; only the department of information was left, and all rights were transferred to the new position of chief engineer.

Chief Deputy of V. F. Utkin (1972)

After the death of M. K. Yangel, V. S. Budnik worked a half-year with V. F. Utkin. Despite their brief time working as a team, Budnik participated in planning the prolongation of the elaborations started by Yangel. But there were organizational difficulties in realizing DBYu's scientific research interests in creation of an academic rocket institute. Therefore, Budnik proposed transfer to a system of the national academy of science of Ukraine in view of the need to strengthen scientific administration of the space-rocket institute.

Life in Science (1972–2003)

By the beginning of the 1960s V. S. Budnik, as Yangel's chief deputy, encouraged opening in Dnepropetrovsk an academic institute in support of DBYu scientific design activities. In the institute at that time the nominal specialist on space-rocket subjects was one doctor of sciences. Therefore, all departments of a rocket profile were joined in the department led by Budnik. He formulated the main complex scientific direction for optimally designing space rocket systems.[37] Working simultaneously with the deputy director of the institute on scientific activity, being as a matter of fact scientific chief of several departments, Budnik created the scientific school for rational design of rockets and space vehicles by those who applied. Based on the vital problems arising from DBYu's work on

fourth-generation rockets, several departments under V. S. Budnik's control were elaborating scientific design fundamentals. The next works were as follows:

- On simulation models of operation of guided-missile systems in view of necessity of overcoming of an echelon antimissile protection;
- On chilldown of cryogenic components in a "Zenith" rocket tank;
- On optimization of power capabilities for the different skeleton diagrams of rockets and conditions of usage in view of the schedule of applying of a rocket grouping.[38]

After the Ukraine obtained independence, V. S. Budnik and the disciples of his school took part in the formation of space programs in that country. Budnik was deeply involved in the conversion of know-how and elaborations of a missilery.[39] A crucial new engineering based on use of rocket engines to extinguish gas fires, oil-well flowings, and oil spills was offered. The projected installations were using engines of decommissioned rockets and had no world clones. The parameters, obtained in experiments, of the installations for extinguishing fires showed considerably greater efficiency than anything else available.

Participation of academician Budnik in the activity of NAS of Ukraine sessions and in the special council on defense of theses was creating the highest level of the requirements, always being a school for both young and venerable scientists.

The Contribution of V. S. Budnik in World Advance of a Missilery

The main activity of V. S. Budnik was a deep, direct participation in the creation of three generations of rockets and scientific support on creation of fourth-generation rockets. The first-generation, ground-based rockets in the Soviet Union (in accordance with classification by V. F. Utkin and J. A. Mozzhorin[40]) was characterized by open launching, by use of a conventional-blast warhead, by growth of shooting range, and by battle readiness. In the development cycle of first-generation rocket, at a stage of becoming rocket and space technology (RST), Budnik participated as a first- and second-level leader, simultaneously learning and designing, both manufacturing and testing rockets, and perfecting the skill of working with people.

The process of rocket creation and how it was occurring in the Soviet Union represented a synthesis of creative activity among hundreds and thousands of engineers, scientists, managers, and workers. Naturally, there was a question about whether the innovations determining progress belonged to their direct au-

thors or to the main or chief deputy designer, whoever gave their approval on realization of a rocket design. The big distance from idea or invention to its inculcation was not a secret. To estimate the efficiency of a proffered innovation, its reality or utility, there was a deputy of the Chief Designer, V. S. Budnik, in DBYu, who saw further than others and assessed the level of risk associated with an innovative intrusion. Budnik was selecting the most perceptive ideas, going ahead in time on elaboration of new rocket designs and new principles for resolution of military problems, which enabled DBYu to become a world leader in rocket production of rockets.

The second generation of rockets was characterized by an increase in flight range and creation of intercontinental ballistic missiles (ICBMs), by use of a nuclear charge, and by going from low-boiling to high-boiling propellants. In the United States, the problem of improving rocket readiness was solved by a transition to solid-propellant rockets, but the Soviet Union created ampoulized-liquid rockets. The second generation ended with creation of ICBMs of distance action (IBMDA)—8K71 (S. Korolev, 1960) and 8K64 (M. Yangel, 1961). The main problem of this time was readiness of a rocket for launch, the solution to which involved the maintenance of reliably functioning rockets filled with aggressive propellants, even after several years of deployment on combat duty, and the eventual creation of solid-propellant rockets.

The third generation of rockets reflected the military doctrine about no first use of the nuclear weapon. It demanded having retaliatory rockets capable of inflicting unacceptable damage on the attacker. The rockets created at this time had the shaft launcher, capable of surviving an opponent's nuclear attack. Development of the third-generation Soviet rockets was characterized by a competition (sharp enough) of three design bureaus—S. P. Korolev's (later V. P. Mishin's), M. K. Yangel's, and V. N. Chelomei's. Nevertheless, 7 out of 10 basic rockets being used by the Soviet military during 1963–1972 were rockets from Dnepropetrovsk DB.

The fourth generation of rockets was created in conditions of necessity to provide launching and reliable flight of rockets vulnerable to the effects from a nuclear explosion. The rockets created at this time, on the one hand, were steady against electromagnetic radiation from a nuclear-explosion zone, and on the other hand, had mobile railway or ground launching. Reliability of these rockets was confirmed by the opportunity to resist the strategic defensive initiative (SDI) of the United States. Creation of this generation of rockets, which were capable of reaching the opponent's territory even if the SDI program was realized, rendered that program inefficient. In creation of the fourth generation of Soviet rockets, the main role belonged to DBYu and its General Designer V. F. Utkin. The sci-

entific support of a series of directions of creation of rockets of a fourth generation was being provided by scientific collective of the institute of technical mechanics (ITM) of Ukraine's national academy of science (NAS) under V. S. Budnik's management.

The figure below and the table on the following page indicate V. S. Budnik's place in the advance of missilery, in elaboration of rockets, and in the progress of space and rocket technology.[41]

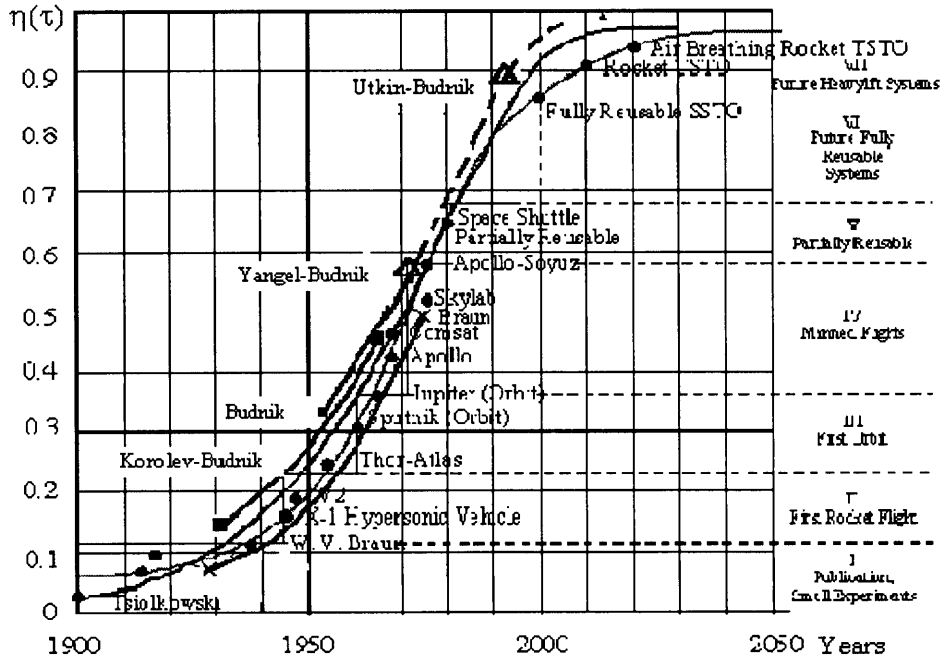

Figure: Progress of space and rocket technology.

Budnik as the Man

The long, creative life of outstanding rocket designer V. S. Budnik, marking in this year [2003] the 90th anniversary of his birth, is a unique phenomenon in rocket and space engineering. It is necessary to tell about his remarkable human qualities. He was characterized by the modesty of a great scientist and pioneer of rocket motion, by exclusive diligence, by internal discipline, by a vast scientific and technical outlook, by boldness, by purposefulness, by skillful listening, and by utter devotion to concerns of business and country. He remembers his teachers—S. V. Ilyuchin, Yu. A. Pobedonoszev, and S. P. Korolev—with thanks.

No.	Years	General Designer/ Deputy	Director/ Chief Engineer	State order on activity	Projects	Tests (exp., bench)	Surrender to the customer	Development DB	Termination or transfer of the booking	Awards
	Criterion			K_1	K_2	K_3	K_4	K_5	K_6	K_7
1	1951–54	V. Budnik	L. Smirnov	4	1	3	0	0	0	0
2	Per Year			1.3	0.3	1	0	0	0	0
3	1954–71	F. Yangel/	L. Smirnov/	36	15	29	13	10	7	7
4	Per Year	V. Budnik	A. Makarov	2	0.8	1.6	0.72	0.56	0.39	0.4
5	1971–90	V. Utkin/	A. Makarov/	18	17	35	34	1	6	16
6	Per Year	V. Budnik/ L. Kuchma/ S. Konuhov	L. Kuchma/ L. Yagdjiev	0.9	0.85	1.75	1.7	0.05	0.3	0.8
7	1991–94	S. Konuhov/	Y. Alekseev/	2	1	1	3	—	1	1
8	Per Year	A. Maschenko	A. Korotkov	0.5	0.25	0.25	0.75	—	0.25	0.25

Table: Comparative characteristics of activity of DBYu chief designers.

This author worked with Budnik in scientific council on defense of theses for more than 10 years. It was the years 1980–1990. I learned much from him. The opinions of Budnik always were a reference point for me in decision making, and that never let me down. His activity, biotic creed, natural inquisitiveness, decency, and accuracy to family can be, in this frail time, an example for our corrupted youth. All his life Budnik adhered to the precepts of V. S. Ilyuchin. About Budnik, very little is written. According to the Soviet tradition, this only supported the "cult" of the Chief Designer. Because to see in the shadow of Korolev, Yangel, and Utkin even a talented designer, someone who was not conceding to these world heavenly bodies, was unwanted. But the world scientific elite of space technology should know those to whom this engineering is obliged. I hope this chapter will open to the world scientific community the person of V. S. Budnik as greatest designer and outstanding scientist.

Notes

[1] In this connection it is possible to adduce a significant example. In the 1970s the aviation DB of N. D. Kuznezov (Samara) on competitive beginnings made a rocket engine (which one has not gone to practice). This engine remained modern during 30 years and was purchased by the United States already presently.

[2] V. S. Budnik, From Attack Aeroplane IL-2 Up to Space Rockets – Memory (Dnepropetrovsk, DSU: 1993). 44 p.

[3] Budnik, From Attack Airplane, 1993.

[4] Budnik, *From Attack Airplane,* 1993.

[5] N. I. Turin, "About Life and Activity of Vasiliy Sergeevich Budnik: Speech on Ceremonial Meeting about a Case 75 Years from Birthday."

[6] Budnik, *From Attack Airplane,* 1993.

[7] B. E. Tschertok, "Rockets and People," *Engineering* (1997).*

[8] All remaining creators of the A-4: Chief Designer Wernher von Braun, chief of center Peenemünde Walter Dornberger, main technologist Hans Lindenberg, and also Bernard Tessman, Kurt Debus, Rudi Beichel—only 400 men, including 150 direct implementators of A-4,—in a course of an operation "Paperclip" were forwarded in the United States. I. Afanasiev, "Sandal Tree," *M-Hobby*, Issue 9 (1997), 34 p.

[9] Budnik, *From Attack Airplane,* 1993.

[10] Afanasiev, "Sandal Tree," (1997).

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* **Publisher's note:** In the time since this paper was presented, English translations of *Rockets and People* by Boris E. Chertok, in three volumes, have been published by the NASA History Office. Volume 1: 2005, ISBN 0160732395; Volume 2 (Creating a Rocket Industry): 2006, ISBN 0160766729; Volume 3 (Hot Days of the Cold War): 2009, ISBN 9780160817355.

[11] Afanasiev, "Sandal Tree," (1997).

[12] Budnik, *From Attack Airplane,* 1993.

[13] Soviet specialists were attracting German specialists for the help in disassembly of missile weapon in three times less than the U.S. one (and their rank was much lower), from which one hereby rocketeer there was one H. Gröttrup. These specialists were taken to the Soviet Union only after the first launches by the Germans with W. von Braun of rockets V-2 in the United States in October 1946. Created closed organization (from 150 specialists) in city Ostachkov (150 kilometers from Moscow) in a year presented the project of a rocket H-1. Its protection in the Research Institute 88 showed, that our own projects have reached a high level and we do not require the help of the Germans. A bit later German specialists began to return.
Afanasiev, "Sandal Tree," (1997).

[14] The similar history with "Katucha" is known, when the Germans attempted to repeat sample of "Katucha" at Czechoslovak plants. But they could not obtain a similar weapon up to the end of war. For example, Czech steel could not substitute for Soviet.

[15] Afanasiev, "Sandal Tree," (1997).

[16] V. Pappo-Koristin, V. Platonov, and V. Paschenko, "Dneprovskiy Space–Rocket Center. Short Handwriting of Becoming and Development," *DAZ-YuMZ-DBYu: The Chronicle of Dates and Events. YuMZ-DBYu* (1994), 180 p.

[17] Budnik, *From Attack Airplane,* 1993.

[18] For example, a rocket R-1 had 30,000. Turin, "About Life and Activity."

[19] Pappo-Koristin et al., "Dneprovskiy Space–Rocket Center," 1994.

[20] Turin, "About Life and Activity."

[21] Pappo-Koristin et al., "Dneprovskiy Space–Rocket Center," 1994.

[22] Anything new in the proposal to use higher-boiling components, in particular nitric acid, was not. Using such oxidants were mastered in the 1930s (Glushko). In the 1940s the similar projects appeared in Germany (project of W. von Braun of a rocket A-8 with distance of 600 kilometers).

[23] Pappo-Koristin et al., "Dneprovskiy Space–Rocket Center," 1994.

[24] Afanasiev, "Sandal Tree," (1997).

[25] Afanasiev, "Sandal Tree," (1997), p. 7.

[26] Pappo-Koristin et al., "Dneprovskiy Space–Rocket Center," 1994.

[27] The phenomenon of popularity of Yangel was contained in his lack—in poor knowledge—of details of missilery. But he always trusted and always was grateful to competent subordinates and took their proposals in the implementation.

[28] In subsequent, already "on end of USSR" DBYu had undertaken implementation of creation of SPRM of large thrust (in the affiliate in Pavlograd) for military missiles. But direction had not given any outlooks in a peace outer space exploration in Ukraine.

[29] V. F. Prisniakov, "About Development of Mechanics with Reference to a Rocket Manufacturing in Ukraine," *Applied Mechanics* Vol. 39, No. 6 (2003): pp. 34–62. V. Prisniakov and N. Sitnikova, "The Peak of Rocket Production: The Designer of Ballistic Missiles V. F. Utkin (1923–2000)," Paper IAC-02-IAA.2.1.03, *Proceedings of the World Space Congress 2002*, Houston, Texas, 10–19 October 2002. Abstracts Book, *The Man Face of Space.*

[30] Budnik was writing about this feature of Yangel: "Michael Kuzmich was a deep Party man. Communist Yangel was considering creation of space-rocket engineering the as a major party mission first of all."
V. S. Budnik, "About Life and Activity of M. K. Yangel: Transaction of Scientific Readings on Astronautics," *IIET AS USSR* (1984).

[31] V. S. Budnik, "About a Team Working with M. K. Yangel: Speech on General Meeting of Department of Mechanics," *AS USSR* (23 October 1991).

[32] L. V. Andreev and S. N. Konupov, "M. K. Yangel—Chief Designer of Space-Rocket Systems," *Space Science and Technology* Vol. 2, no. 2 (1996): p. 58.

[33] The generous and baseless transfer of marine subjects to V. P. Makeev in Miass. Baseless because it was all the same in 20 years. DBYu was compelled to return to marine rockets. Andreev and Konupov, "M. K. Yangel," (1996): p. 58.

[34] Andreev and Konupov, "M. K. Yangel," (1996).

[35] Usage of "Zenith" in the program Sea Launch plays most likely symbolical, rather than main role in realization of capabilities of Ukraine as space state.

[36] How and when in a burn-time by the Chief Designer of a plant the speech against the minister at an analysis of emergency of a rocket was worth for Budnik to assign Chief Designer of SDB-586.

[37] V. V. Pilipenko, "Vasiliy Sergeevich Budnik," *Technical Mechanics* No. 1 (2003): pp. 3–9.

[38] Pilipenko, "Vasiliy Sergeevich Budnik," (2003).

[39] Pilipenko, "Vasiliy Sergeevich Budnik," (2003).

[40] A. V. Minaev, editor, "Soviet Military Power from Stalin Up to Gorbachev," The House, *Military Parade* (1999).

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