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Chapter 3

The Peak of Rocket Technology: The Designer of Ballistic Missiles V. F. Utkin (1923–2000)*

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Abstract

For 40 years a dizzy ascent of the beginner-designer V. Utkin made a dizzy ascent up the ladder of space-rocket's Olympus to become chief designer of a new generation of strategic rockets: SS-17, SS-18, SS-24, and rocket-carrier "Zenit." With V. Utkin's participation, the following results were achieved: (a) a railway rocket complex; (b) a method of management with the help of command rockets; (c) a method for defining the characteristics of how to overcoming anti-missile defenses; (d) intercontinental rockets with increased accuracy, survivability, and maneuverability; (e) a commanding rocket; (f) and also design decisions: (fa) flight management of solid-propellant intercontinental ballistic missiles by means of a deviating head part; (fb) management of solid-propellant rockets by the method of injecting gas into the supercritical part of the nozzle; et cetera. The place of V. Utkin in development of world rocket and space technology is shown.

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His scientific-design activity is analyzed. Criteria of comparison for activities of the main rocket designers are offered. Achievements of the main designers in Design Bureau Yuzhnoye (DBYu), M. Yangel and V. Utkin, are compared. The reasons for DBYu successes are analyzed. Memoirs by author V. Prisniakov in collaboration with V. Utkin are included.

We have forged ardent wings
To our country and our century.
V. F. Utkin

Introduction

Progress as a direction of scientific, engineering, or societal development has a wavy character as it transitions from less perfect to more perfect [4]. Rudi Beichel has shown [1] that development of rocket and space technology (RST) also is wavy. An RST development curve for the 20th century and for the next 40 years of the 21st century is shown in Figure 1. This graph depicts the launches of spacecraft and their designers, on a logistical-type curve. Apparently, after a period where new ideas, new technologies, or new opportunities occur (about 40 years), a period of sharply increased progress in rocket and space technology (about 50 years) takes place. On the crest of each wave there are outstanding people who accelerate progress. Then the pace of progress reaches its "saturation" and falls. The most rapid pace of RST development, from the 1950s through the 1980s, demanded the presence of leaders of a new type. The rocket competition between the United States and the Soviet Union only began to appear in the 1950s, and it caused the appearance of M. Yangel and S. Korolev. Continued growth in the pace of space-rocket engineering created more military and space rocket complexes in the Soviet Union than in all the world's other rocket organizations and brought to leadership an academician such as Vladimir Fedorovich Utkin. It was a personal tragedy for such outstanding persons as V. F. Utkin that, after reaching the highest positions in the creation of rocket technology, they promoted over time the destruction of their own creations. They created the preconditions for such destruction by outstripping the development of a human society that apparently was unready to use a weapon whose power was capable of destroying mankind. And at the end of the previous century the barbarous destruction of rockets created by human work began leading to mistrust and because of their competitive use for cheap access to space, increasing fear of a return to their use as weapons. During this period people demanded "executioners of progress," but the world community paid for these admitted mistakes.

Given the wavy character of progress, however, rocket and space technology undoubtedly will lead in the near future to its revival and a new stage in world civilization. New problems will cause a demand for this, because mankind cannot live without space. We shall recollect V. F. Utkin's recent forecast:

> What do we want to receive from Space? I present that further development in this sphere of activity of mankind will go in two ways. The first: commerce—a wide stream, the rough river current in Space. And commerce in Space is communication, TV, manufacture of new materials and medicines, sounding of the Earth and so on. It—the market—is rather similar to usual, terrestrial activity. And the second part, more important for mankind, involves decisions about fundamental problems: condition of the ozone cloud; predicting earthquakes; a location in space to dump the most terrible waste products of earthmen's activity—in particular, waste products from atomic power stations, the nuclear industry, the chemical industry . . . And a meeting of the Earth with asteroids? It is a huge problem. Scientists of nuclear physics have paid attention to it. They have offered to destroy these dangerous space bodies or to change their orbits, but without perfect rocket engineering, doing it is impossible [5]!

Recently the Earth faced (the truth, for a while) one of the most dangerous problems in its existence—the possibility of collision in the very near future with an enormous approaching asteroid. Doubtless, successful resolution of this problem depends on achievements of V. F. Utkin's team. But to gain greater insight into the place of academician V. F. Utkin in rocket and space technology, briefly we shall consider briefly the development of that technology during the last 100 years.

Brief History of Rocket and Space Technology

Pioneers of Rocket Engineering

In the first 20 years of the 20th century space-rocket technology began to take the first steps, the first real successes. K. E. Tsiolkovsky, developing the theoretical basis of rocket movement, stated many constructive ideas for realizing use of rockets for interplanetary travel. The application of rockets for development of space was proved by K. E. Tsiolkovsky in the beginning of the century. He established the basis of rocket theory and liquid-propellant rocket engineering (LPRE), developed the theory of flight for multistage missiles, and considered the problem of landing space vehicles on planetary surfaces. K. E. Tsiolkovsky first proved the future need for launching artificial satellites of Earth (ASE) and for creating the stations in Earth orbit where humans could work.

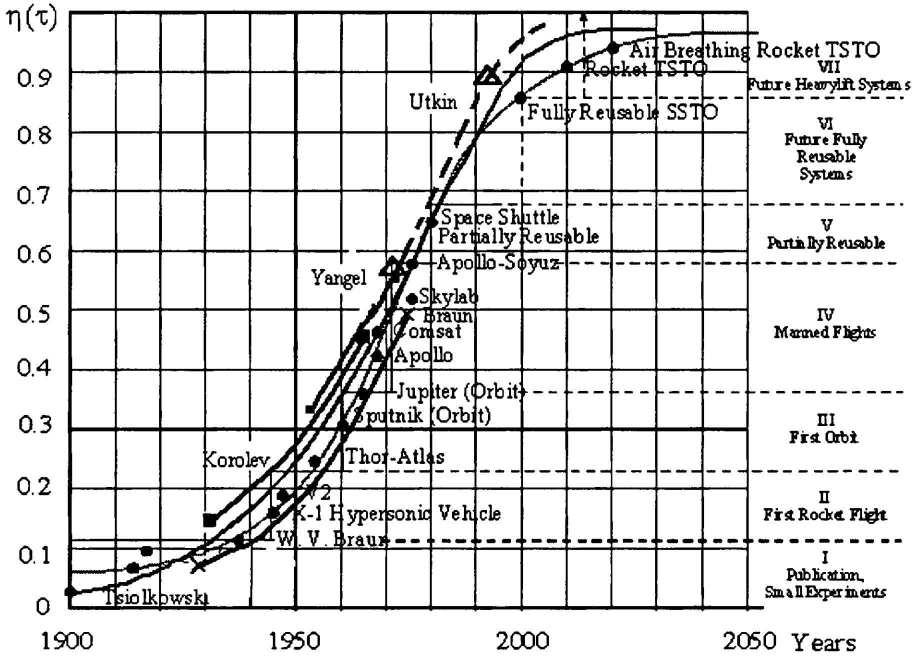

Figure 1: Progress of space technology.

He considered for the first time the problems connected with realization of rocket flight—from medical and biological problems of long space flights to especially technical problems. His original ideas were further realized in the regenerative cooling of the combustion-chamber walls by fuel; a pumping system for fuel; optimum flight trajectories; and graphite rudders. K. E. Tsiolkovsky's study of various liquid-propellant combinations were continued by F. A. Tsander and completed by V. P. Glushko. Part of K. E. Tsiolkovsky's ideas surpassed his time and were not realized until now. These especially concerned the influence of space on the future development of human life. In the person of K. E. Tsiolkovsky mankind had the person who successfully connected two centuries—the 19th as the century of steam, and the 20th as the century of space.

A feature of F. A. Tsander's work is the practical realization of rocket-engine designs. F. A. Tsander designed, made, and experimentally developed a number of jet engines, which contained all the basic elements of modern LPRE. Under his management the GIRD-X liquid rocket was completely developed and passed flight tests. The rocket engine created by V. P. Glushko passed captive tests on S. P. Korolev's rocket plane, the first flight of which was accomplished in 1940. In the United States, R. Goddard conducted theoretical and experimental research on Solid Propellant Rocket Motors (SPRM) and LPRE in parallel with

F. Tsander. He launched the world's first liquid-propellant missile. Similar works were carried out by M. Valier, J. Winkler, W. Dornberger, W. von Braun in Germany, by H. Oberth in Germany, Austria, and Romania in different years, and by R. Esnault-Pelterie in France. H. Oberth considered the equations of rocket movement, the circuits and design features of rockets, kinds of fuel and the delivery system, methods of combustion-chamber cooling, guidance of a rocket in flight, et cetera. At Vienna University in Austria, Dr. E. Sänger experimented with rocket engines. In France R. Esnault-Pelterie carried out experiments with various rocket fuels, over time (1913-1935) developing the theory of jet movement.

Adolescence of Rocket Technology: First Utilization (1939–1945)

The first effective utilization of rockets as powerful weapons was carried out in the Soviet Union by creation of solid-propellant "Katucha" projectiles (I. Gvaj, G. Langemak, and V. Barmin). If fundamental work on rocket technology had poor financing, practitioners nonetheless carried it out with enthusiasm, and military interests gave a powerful push for its development. Other opportunities for rocket engineering arose with development shells like the "Katucha." Creation of the "Katucha" serial launcher was an outstanding achievement in rocket technology. During the Second World War, the Soviet Union developed and produced 36 types of these rockets.

The German army's interest in rocket engineering enabled an interplanetary-spaceflight society to achieve outstanding results. The engine on the von Braun group's first rocket, the A-1, had a 3 кN thrust. In 1937 the rocket research center in Peenemünde was organized and offered fantastic opportunities for those times. Subsequent developments led successfully to the large A-4 (V-2) rocket, capable of delivering a warhead weighing 1 ton over a distance of 275 km, and also to initial work on the A-9/A-10 two-stage missile, capable of flying about 5,000 km. The second developmental stage of rocket technology (1938–1945) was wartime, a time of great opportunities for rocket engineering and realization of various projects on the military use of rockets. The post-war period began with the victors exporting German technical materials on rockets. Both in the Soviet Union and the United States, competition began on creation of the rocket weapon. It is necessary to point out, however, that the acuteness of need for the rocket weapon was different for the United States compared to the Soviet Union.

The United States had a powerful naval fleet and a large number of military bases around the Soviet borders, which made it possible to threaten aerial bombardment of Soviet territory. For the Soviet Union to reach U.S. territory, ballistic missiles were more important. Consequently, the Soviet initiative was to develop rockets that met the appropriate military requirements: at the beginning—range, range, range; later on—accuracy, accuracy, accuracy; further on—survivability, survivability, survivability; and finally—readiness, readiness, readiness [5, 7].

Technical Preparation for the Conquest of Outer Space: Creation of Long-Range Missiles

Obtained by the Soviet Union, the German information on creation of ballistic missiles did not play a major role. It most likely had a psychological, educational character. This information convinced them of the possibility of creating powerful rockets capable, on the one hand, of carrying an explosive over large distances and, on the other, capable of being a vehicle for interplanetary travel. The essential value of German rocket complexes (by the way, not reflected anywhere in the literature) was their use in training young space-rocket engineering experts. Sample V-2s were in all institutes of the Soviet Union, including the Baltic State Technical University "Voenmech" in Leningrad where Vladimir Fedorovich Utkin studied in 1946–1951. Soviet use of German experience went on for a while, similar to later technical development in Japan: rapid acquisition of technological experience from elsewhere in the world and quick internal transition to new levels. V. F. Utkin has described this stage as follows:

> At the beginning for R-1 it was necessary to make the engineering specifications for a batch production. Slowly we changed specifications; we introduced some improvements. Then we saw that here and there we had made mistakes; we corrected them. It was a magnificent school. So, work with R-1 was a serious and important step in the development of our rocket engineering, and on no account should its role in history be underestimated (on [5], p. 40). In the United States, at the first post-war stage, rocket development proceeded with use of German scientists led by W. von Braun (about 100 persons), uniting the intellectual-scientific potential of Germany and the industrial power of the United States. Interest in rockets was awakened in the United States with war in Korea. The German experts in American firms improved the A-4 rocket, and they created a "Saturn-V," rocket which made possible the landing of people on the Moon. After this flight the dependence of the United States on German scientists was finished. The Soviet designers' independence from the dictatorial authority of German command allowed the Soviet Union to win the competition with the United States with respect to military rockets: the majority of tactical parameters and specifications rendered Soviet rockets more powerful. Antagonism with Americans is not in quantity of rockets; it is in the design idea (V. Utkin, *Red Star*, 23 March 1991).

That hundreds of experts in rocket technology from the United States, Western Europe, and China rushed to receive information from Russia and Ukraine after disintegration of the Soviet Union confirms this idea.

Stages of Creation of Rocket Weapons and Activity of V. F. Utkin

When Vladimir Utkin, the young graduate of Leningrad's Baltic State Technical University, "Voenmech," arrived in Dnepropetrovsk in 1952, the R-2 rocket of S. P. Korolev's design office came into operation with better tactical parameters and specifications (TPS) than the A-4. Batch production of this rocket was carried out by Yugmach in Dnepropetrovsk. The main design bureau (DB) series designer in Dnepropetrovsk was V. S. Budnik, and the first technical experience for beginning engineer V. Utkin, the future general designer, was to support the R-2 rocket by finding room for spare tools and accessories in an automobile [7]. In 1955, S. P. Korolev handed over to the military rocket R-5 with a range of 1,000 km and options for carrying new varieties of warhead equipment—chemical, nuclear, radiation, et cetera. The Dnepropetrovsk experts (V. Budnik as the plant's main designer since May 1951 ([9], p. 53), N. Gerasuta, V. Kovtunenko, P. Nikitin, I. Ivanov, F. Falunin, et cetera) had already gone through S. Korolev's DB, a magnificent technological school for serial improvement of rockets.

The decision of the Council of Ministers of the Soviet Union on 13 February 1953 to develop the preliminary design of R-12 (8K63), a ballistic missile of average range that burned high-boiling toxic propellants, was entrusted to V. Budnik's DB [5, 6]. Such a project, based on a range of 1,500 km [10], was prepared. In April 1954 a factory design department was transformed to a special design bureau (SDB-586). Unknown for Dnepropetrovsk, M. Yangel ([9], p. 56), the main engineer of research institute NII-88 [10], was appointed its main designer in July 1954. Up to the moment of M. Yangel's arrival in Dnepropetrovsk Vladimir Utkin had climbed the rungs of the official engineering ladder—lead engineer, head of a group, sector chief, and secretary of the party organization DBYu. Good engineering preparation, aspiration for self-improvement, constant thirst for new knowledge, splendid organizing abilities, and knowledge of the world furthered Vladimir Fedorovich's promotion ([8], pp. 5–6).

The first generation of ground-based rockets in the Soviet Union (in accordance with the classification of V. F. Utkin and J. A. Mozzhorin [2]) was characterized by open launching, use of a usual blast warhead, increased shooting range, and battle readiness. During the development cycle of the first-generation rockets, at an early stage of RST, V. F. Utkin participated at a primary and secondary level, simultaneously learning how to design, manufacture, and tests rockets, and developing the skills to work with people.

The process of creating a rocket and how that took place in the Soviet Union represented a synthesis of creative activity among hundreds and thousands of engineers, scientists, managers, and workers. Naturally, there is a question whether the innovations that determined progress belong to their direct authors or to the main designer who ultimately approved the rocket design. It is no secret that a vast distance lies between an idea or invention and its acceptance in a final design. To estimate efficiency or realistic utility of a proffered innovation, the main designer should see further than others; he should estimate the degree of risk associated with adopting an innovation. It is simply scientific estimation, the creative work, which entitles co-authorship. By the time of M. Yangel's arrival in Dnepropetrovsk, V. Utkin had risen from the young engineer to the Party secretary of SDB-586. He who understands the Soviet system knows an organization's successes depend very much on the forcefulness of the Party secretary. By the time of M. Yangel's death, V. Utkin had 20 years of work experience in DBYu, including eight years as Yangel's key deputy (responsible for a rocket design) and three years as his first assistant, who actually defined internal work at DBYu. Therefore a large share of the enormous volume of scientific and technical solutions that new main designer V. Utkin inherited at DBYu in 1971 already reflected his creative and organizing work (see Figure 2). V. Utkin already had about 50 inventions, the monograph "Valves in Onboard Systems of Long-Range Missiles and Spacecraft" (editor M. Yangel, co-authors S. Titov, L. Nazarova, V. Prisniakov et al.), and scientific articles. Therefore, most of the enormous volume of scientific and technical solutions at DBYu owed something to V. Utkin's management as general designer. He chose the most promising ideas when new rocket designs were being developed or new principles related to military tasks were being decided, which enabled DBYu to become the world leader in the manufacture of rockets. Vladimir Fedorovich assessed the main designer's role as follows: "The situation changed radically when we created '36th machine.' Here was increased diameter, power, and range, but these external changes are not the point. Here, already, was a new ideology in rocket technology. It was the creation of an original, reliable, and complex rocket in which all was balanced" ([5], p. 44). The activity of the main designer is not only in work skill but also to prove what is right. Mistrust of an innovation is in people's blood. Also, that it is a sin to conceal. In those years one suddenly appeared lifted on the crest of a wave; others worked, not causing interest in "government circles." But Utkin "did it all his own way" (M. Rebrov, *Red Star*, 23 March 1991).

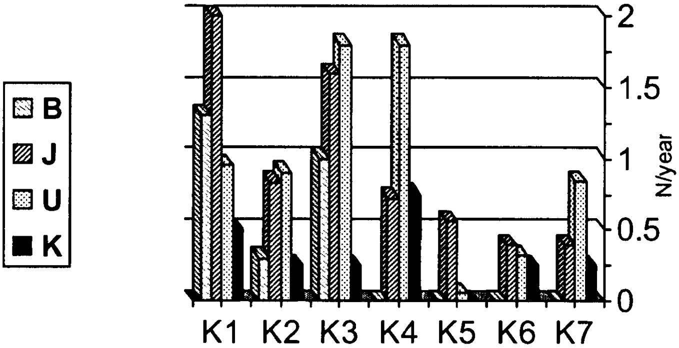

Figure 2: Comparison of the effectiveness of activity of DBYu in Dnepropetrovsk during management by V. Budnik (B), M. Yangel (J), V. Utkin (U), and S. Konuhov (K).

For this reason, during the last decade of the last century, the rocket community lived in an atmosphere favoring revelation of Yugmach's secrets. Now we have no basis for questioning or doubting whether the idea for beginning "Zenit" came into Vladimir Fedorovich's head, as did visions of transforming it into the "Energie" rocket booster or placing a separable warhead on some ([5], p. 115). But it is necessary to remember that the main designer always must accept responsibility for pursuit of a completely new, risky direction and must answer in case of failure.

The second generation of rockets was characterized by an increase in flight range and creation of intercontinental ballistic missiles (ICBM), use of a nuclear charge, and the transition, basically, from propellants with low boiling points to those with high boiling points. In the United States the problem of increased readiness of rockets was solved by a transition to solid-propellant rockets with solid propellant; in the Soviet Union it was through creation of ampoulized liquid rockets. The second generation ended with creation of intercontinental ballistic missiles of distant action (IBMDA)—the 8K71 (S. Korolev, 1960) and 8K64 (M. Yangel, 1961). V. F. Utkin participated actively and directly in the development of rockets of this generation, initially as a department chief, later (after 1960) as the main designer's deputy responsible for organizing release of the drawings and engineering specifications, for manufacture and experimental improvement of rockets and their units, and as the main designer's first assistant (after 1968). The main problem during this time was a rocket's readiness for launch, that is maintaining rockets filled with active propellants to ensure they would function reliably after several years of waiting to be fired. This central problem also was solved directly by V. F. Utkin [7]. It was really a state approach that avoided enormous cost for the motherland because, compared to deployment of solid-propellant rockets, the solution chosen demanded considerably smaller maintenance costs to achieve the supreme degree of battle readiness.

The third generation of rockets reflected the military doctrine of "no first use" of the nuclear weapon. It required having sufficient rockets to retaliate and inflict unacceptable damage on the attacker. The rockets created at this time had the silo launcher, capable of surviving an opponent's nuclear attack. Development of the third generation of rockets in the Soviet Union was characterized by a sharp competition among the three main design bureaus of S. P. Korolev (later on V. P. Mishin), M. K. Yangel, and V. N. Chelomei. Nevertheless, seven out of ten basic rockets in Soviet armies during 1963–1972 were from Dnepropetrovsk Design Bureau. In this period General Designer V. F. Utkin not only continued and creatively finished the development begun in M. K. Jangele's time, but also prepared the foundation for achieving the pinnacle of practical rocket technology. Silo-based rockets with "mortar" launching and increased survivability, availability, and accuracy were perfected. V. F. Utkin participated directly in developing and introducing the idea of rockets with multiple warheads and individual guidance of each warhead to a target, introducing into the structure of the military rocket complex (MRC) the orbital warhead capable of striking from any direction, and in creating solid propellant rockets controlled by means of a deviating warhead. With participation by IAA academicians, V. F. Utkin formulated a little-known, original war-management method that used "command rockets" and, also, a method for defining the characteristics of means for overcoming antimissile defenses.

The fourth generation of rockets was created to provide launching and reliable flight by reducing vulnerability to the effects of a nuclear explosion. The rockets created at that time, on the one hand, were hardened against electromagnetic radiation from a nuclear-explosion zone and, on the other hand, had mobile railway or ground launching. The reliability of these rockets even was checked against the Strategic Defensive Initiative (SDI) of the United States; rockets capable of reaching the opponent's territory even if SDI became a reality obviously made that program inefficient. The main role in creation of the Soviet Union's fourth-generation rockets belonged to DBYu and to General Designer V. F. Utkin. The well-known R-36 ("Satan") became the crown of military rockets, capable of launching directly in a nuclear environment and having (nor hardly ever would have) no combat equivalent in the world. Railway-based, solid-propellant intercontinental missiles with an engine uniquely guided by injection of gas in a supercritical part of the nozzle (do not have any analogues and unlikely to have any in future) were developed based on existing ideas concerning possible structures, by technical "saturation." Creation of a "Zenit" rocket (as the basis for the first stage of the reusable "Energia-Buran" space transport system) defined the 20th century as the century of astronautics. This non-polluting space carrier-rocket is considered to be the pinnacle of rocket creativity, the peak of practical rocket technology all over the world. It simultaneously featured V. Utkin's creation of a system that allowed completely automated rocket launching.

> This was cleanly a "space" machine. And we at once changed approaches to its creation. I came to an agreement with Valentine Petroviche Glushko that it was necessary to go from a simple system to a complex system, from the middle-class "Zenit" launch vehicle to the "Energie" booster by using the first stages from "Zenit." We presented him the same number of carriers. The first was the easy machine, up to 5 tons, with number "55." "Zenit" was afterwards. And at last, the first rocket stage from "Zenit" was "Energie." . . . I remember perfectly, how we made arrangements with Valentine Petrovich. Moreover, I told him, we shall launch 10–15 "Zenit," and his "Energie" will come up. And the first rocket stage for it already will be tried out. So, the second feature of "Zenit" was unification with "Energie" ([5], p. 115–116).

By the end of the 20th century progress in rocket technology terminated, and the period of its improvement for practical, peaceful commercial use began. For DBYu General Designer V. Utkin, this was not unexpected. He created and used extensively a method of solving design problems with a choice of tactical characteristics of rocket systems in regard to complex "cost effectiveness" criteria. And he began to realize the large-scale program of going into space by conversion of DBYu rockets (the "Ziclon" carrier-rocket), launch of satellites ("Space-1500," "Interspace," "Oreol," "Zelina-2"), and creation of automatic universal orbital stations (AUOS—"Ocean").

V. F. Utkin and Design Bureau "Yuzhnoye"

DBYu as Peak of Development of Space-Rocket Technology

It is interesting to compare the effectiveness of DBYu activity in Dnepropetrovsk during management by V. Budnik, M. Yangel, V. Utkin, and S. Konuhov. As criteria of comparison we shall take the number of orders (government decisions) on creation of space-rocket technology samples K_1, quantity of completed projects K_2, volume of bench and flight tests K_3, number operationally accepted (handed over to the military, on an economy) K_4, DBYu development of structure K_5, quantity of work stopped or transferred to other organizations (as the negative factor) K_6, and number of government awards received K_7. Given in Figure 2, the data (in absolute and in specific—for one year of activity) shows the strong and weak aspects of each main designer. It is necessary to say that despite a changed military-political situation in the Soviet Union and the world in 1971–90, General Designer V. Utkin provided one new order per year. It is the sole criterion on which his parameters concede to his predecessor. The quantity of executed conceptual designs for main designers M. Yangel and V. Utkin was close, 0.83 projects per year for the former against 0.9 for the latter. By volume of completed tests, the period 1971–90 slightly exceeded the previous period, 1954–71: $K_3 = 1.6$ against $K_3 = 1.8$. Naturally, one of the central parameters is the number of engineering samples handed over to the military. On this parameter V. Utkin's period more, than in 2.5 times exceeds the previous period: $K_4 = 1.8$ against $K_3 = 0.7$. Generally, it is natural to step up and use opportunities at DBYu, but only V. Utkin might support development of previous ideas!

What V. Utkin Left DBYu

V. F. Utkin headed DBYu for 19 years. During this time, under his management, four strategic rocket systems were developed and handed over to the military, which provided parity of the Soviet nuclear forces with the appropriate forces of the OTAN—more, rather than somewhere in the world. He spoke this way about DBYu in 1990 ([5], p. 61):

> What is DBYu? It is liquid engines—Ivan Ivanovich Ivanov known as the designer. It is the solid-propellant rocket motors of main designer V. I. Kukushkin. It is space vehicles, carriers; all steering machines and devices; tractor DB; solid-propellant and liquid combat missiles. The Soviet Union has had no DB of such scale, except ours! And now, there is none anywhere in the world . . . And what has been made for a short period of time? SS-18 "Satan," "23" of two types—including railway, a unique variant in the world, a "Zenit" rocket, four systems handed over to the military, the "Zelina-2" satellite—radio engineering investigation, the four first stages of "Energie," the first stage for a sea missile . . . And the tractors—65,000.

His successor, DBYu General Designer S. Konuchov, made this estimation of V. Utkin ([5], p. 341.):

> The principle of "double use" rockets was proposed by M. K. Yangel and realized in practice by V. F. Utkin. And not only that! Our firm developed very harmoniously. Our DB structure included a liquid-engine team with only 400–450 persons. But during these years it created 19 engines! The DB for solid-propellant rocket engines created not less than 60 engines! The DB for development of space equipment had 400–500 people. We had a united complex in which different DBs functioned rather effectively when they were directed to work on a unified problem. And the centers of new technologies, and the theoretical departments, and the test base—all that allowed DBYu to very harmoniously develop and create any type of engine for any rocket-propellant components.

V. Utkin's Personal Contributions to the Development of Rocket and Space Technology (RST)

Summing up altogether, it is possible to make the following conclusions about the personal contributions and direct participation of academician V. Utkin in RST development (according to Yu. A. Smetanin's classification [7]):

- solution of a readiness problem by relying on ampoulization to start a rocket;
- increase of a rocket's flight range up to intercontinental (missile R-16);
- increase of a liquid-propellant rocket's survivability at start by silo basing and "mortar' launching by means of a transport starting container and firing the rocket engine in the air above the silo (rocket R-14U, R-16U);
- increase of efficiency of a rocket shot due to application of divided warheads possessing individual guidance to a target and, also, due to introduction into a combat rocket system of an orbital warhead for the purpose of approaching its target from any side;
- creation of new types of mobile starting systems, in particular a railway one (RS-22)—"A feature of this system that distinguished it from all previously existing systems was that the army received it straight from the plant" ([5]; p. 65);
- conversion from military production, that is, re-profiling military missiles and satellites for use in scientific space research and to satisfy commercial objectives ("Kosmos" or Dnepropetrovsk satellite series, "Ocean," AUOS, "Kosmos" carriers, "Ziclon");
- creation of small-sized rockets (MR-UR-100);
- expansion of work in which tactical characteristics were selected based on "cost-effectiveness" criteria;
- creation of rockets with increased resistance to electromagnetic radiation from the zone of a nuclear explosion ("Satan" missile);
- development of principles for management of the flight of solid-propellant intercontinental missiles by means of a deviating warhead or injection of combustion products into a supercritical part of the engine nozzle and realization of the same without having appropriate analogues for design decisions (RSM-52);
- rapid creation of a new direction in Soviet manufacture of strategic solid-propellant missiles;
- creation of non-polluting, completely automated launching, with the most powerful engines in the world and the perfect mass-energy characteristics of a "Zenit" rocket.

The Analysis of Some Reasons of Achievements DBYu

Communication with Production

Under the direction of V. F. Utkin, DBYu made more new rocket systems than all the world's other design bureaus combined. This happened not only because of its top scientists concentrating on RST problems, but because of an advanced unification of design engineers from DBYu and manufacturing engineers from Yugmach. I would like to note a duo of two clever heads—V. F. Utkin and A. M. Makarov—who cooperated successfully for 30 years. This creative Utkin-Makarov team prevented the division of the rocket-delivery stage into two parts: flying tests of DBYu pre-production models, then startup of actual manufacture at Yugmach engineering works. All rocket systems created in DBYu were produced by Yugmach based on DB documentation. This reduced the manufacturing time for a rocket from five years to two–three years. Consequently, V. Utkin managed to create more rocket systems than all other DBs put together.

Another thing that is difficult for the Western experts to understand, because it was uncharacteristic of a market economy, was ensuring the qualitative manufacture of rockets. During the war, and for some time afterward, industrial discipline in the Soviet Union was supported by patriotism and by fear of responsibility for military production (chief of Soviet security L. P. Beriya). In 70–80 years DBYu created a special, fanatical spirit—one devoted to branch. The youthfulness of Yugmach's team aided development. But there also was the special internal reason of providing speed for practical realization of design projects. Special communication with engineering works enabled them to begin a project simultaneously with DBYu: the usual three-link system of "DB—pilot production—series production" under Yugmach director A. M. Makarov was replaced by the double-link system of "DBYu pilot production—series production." Here, both Yangel and Utkin were very lucky that the outstanding production organizer Alexander Maksimovich Makarov had been appointed Yugmach director as far back as 1948. Unfortunately, historians have not yet reflected on the latter's character and role in RST progress. Yugmach rocket production peaked due to the presence of V. Utkin and A. Makarov at the helm over a period of 30 years.

Communication with Universities

This factor concerns personnel updating of Yugmach. At the beginning of June 1951 Dnepropetrovsk automotive technical school was renamed as an institute of technical mechanics and its structure transferred. Later on, in 1952, J. Stalin accepted the decision on the organization at Dnepropetrovsk State University

(DSU) of the closed physics-technical department. In development of rocket technology generally (and rocket engines in particular), Ukraine took a special place. Most general designers of rockets in the Soviet Union (naturally including M. Yangel and V. Utkin) are connected to Ukraine. They were born, studied, or worked in Ukraine: S. Korolev was a student in Kiev. His follower Yu. Semenov, was a graduate of DSU's department of rocket engines (DRE). V. Chelomei was a graduate of KPI and his follower A. Nedaivoda was a graduate of DRE (chief designers of the "Proton" missile). DSU graduate V. Saigak (deputy main designer in Samara) was the leading designer of the famous "A Seven" missile. The outstanding organizer of Soviet rocket technology V. Dogujiev, the last vice-premier minister of the Soviet Union, was a DRE student. Practically all present leaders of DBYu and Yugmach were students in the DSU physics-technical department. The president of Ukraine, L. Kuchma, was a DRE student. You can see that achievements in the Soviet rocket industry were determined by the activity of DSU graduates. The DSU physics-technical department is a unique phenomenon in the world's RST history. During the 50-year history since 1952, it has prepared about 20,000 engineers. V. Utkin began cooperation with DSU in a deputy-main-designer role with the department of rocket engines, where he initiated research on automatic units. Furthermore, he constantly pulsed communication with DSU, and always participated in DSU scientific council work on defense of dissertations.

The monograph written with his direct support, "Valves of Onboard Systems of Long-Range Missiles and Spacecraft" (editor M. Jangele), was for many years the irreplaceable manual for practical designers and students of the Soviet Union.

Students—There was a special selection system for students of the DSU rocket department, where only the gold and silver medalists of a school were admitted. When J. Stalin signed the decree establishing the DSU rocket department in 1952, there was a group of students from all five years in the DSU mechanical-mathematical department who had been gathered from all the high schools in the Soviet Union. It allowed the DSU rocket department, without delay after its formation, to prepare the young engineers, who began working at once on the design and manufacture of missiles (while simultaneously continuing their educational activities). It should be noted that the fanatics of space technology entered the DSU rocket department. Studying there was extremely difficult. Despite admission of the strongest and most talented students to the rocket department, 75 percent who entering the first year did not finish DSU.

Training—There was a special system for training engineers that combined the highest level of theoretical exposure (university courses in mathematics, physics, mechanics, radio engineering, and control) with practical, engineering skills (designing, organizing, and test training). Students did their practical work directly in DB factories. The diploma was executed and defended at the enterprise. The author wrote the textbook on SPRM dynamics under V. Utkin's management [11]. Laboratories were equipped with samples of missiles—from V-2s to new products from DBYu. Only the main designer decided to transfer samples of new rockets that went to the military, and V. Utkin always stood on the high school's side in this business. Therefore, our laboratory of rocket structures had no equal in the Soviet Union. Both Utkin and Makarov always supported construction of new DSU buildings.

The explanation of the phys-tech phenomenon, given a galaxy of outstanding people, lay in the training system that forced them to study well. That was important in training also to lead up any task to metal, to manufacturing. It made a concrete reality of a completed affair. It is no wonder, therefore, that amongst Dnepropetrovsk phys-tech graduates there were also ministers of the Soviet Union, vice premieres of the Soviet Union, the president, and the main designers.

The teachers—Such an education system was ensured by engaging in actively teaching the leading experts from DBYu and Yugmach. As leader V. Utkin understood, this educational process distracted engineers or DBYu division heads from doing their work. But, at the same time, he understood that this teaching work benefited DBYu's future prospects. Therefore, DSU never had problems attracting DBYu engineers for lecturing.

Academic council—The Specialized Academic council on protection of doctor's and master's theses at DSU (chairman V. F. Prisniakov) had an enormous role in improving the professional skill of rocket technology's scientific staff. For 30 years of its existence it defended about 200 confidential doctoral and master's theses on space-rocket subjects. All leading DBYu experts (V. Utkin, V. Budnik, V. Kukushkin, N. Gerasjuta, V. Kovtunenko, V. Fomenko, P. Nikitin, I. Ivanov, and A. Klimov) participated in this Specialized Academic council. Participation in scientific discussions promoted RST development, revealing new perspectives on, or directions for, rocket engineering. Despite his enormous workload, V. Utkin always participated in sessions of this council.

Communication with a Science

The particular position that V. F. Utkin occupied in DBYu fostered cooperation with scientific institutes and an academy of sciences. His personal friendship with AS Soviet Union presidents G. I. Marchuk, A. P. Aleksandrov, and with NASU's B. E. Paton and vice president V. I. Trefilov enabled him not only to tap the full potential of technologically oriented scientific institutes (especially important for the space-rocket branch), but also to involve other scientific organizations in helping DBYu. Welding by explosion of the rocket's ring frames, accomplished by Paton's Institute on Yugmach, still has no technological equal in the world. It is worth noting that NASU's branch of mechanics is where academician V. Utkin was orientated on rocket engineering. The word of V. Utkin was decisive on the question of opening the Institute of Technical Mechanics in Dnepropetrovsk as the lead RST scientific research institution for mechanical-engineering technology.

The International Activity

After the transition in ZNIIMach, academician V. Utkin managed to take advantage of an opportunity to influence the world's development of rocket and space technology, particularly through the Russian-American "Utkin-Stafford" Commission on problems of guaranteeing flights in the "Mir-Shuttle" program and expansion of International Space Station (ISS) operations.

The Progress and the Personality

So, K. E. Tsiolkovsky clarified the principal problems and scientific directions of RST development. Later other scientists—Tsander, Goddard, Valier, Oberth, Glushko, Kondratuk, and Esnault-Pelterie—clarified other problems. These RST pioneers prepared the way for "Katucha" development and V-2. From the perspective of practical astronautics, which demanded the existence of high-powered rockets, the second rather large figure was W. von Braun who was able, on a crest of war, to make the creation of large rockets a reality. S. Korolev, M. Yangel, and W. von Braun actively began to develop a military direction in rocket production, having the ultimate goal of the conquest of space. The services of V. Utkin to RST included not only continuing Yangel's ideas, but also managing after his death to realize at a new level all his conceived, even fantastic, ideas. Yangel's ideas demanded new leadership qualities for their realization; and V. Utkin, a new type of leader, managed with honor what was assigned to him by fate. Actually, DBYu led by General Designer V. Utkin reached the peak of practical astronautics, the peak rocket production. Vladimir Fedorovich was one of the last postwar leaders of a particular kind; he combined the abilities of a manager (basically working with the state military customers), supervisor, and scientist. At the end of the 20th century RST reached a "saturation" point, an innovative plateau that changed basic development requirements. Transition from scientific improvement of rockets to a reduction in their price (accepted earlier in the United States) diluted the role of the general designer's personality within a set of smaller, more technical leadership dimensions. In the long run, we came to three pillars of world astronautics after Tsiolkovsky—to von Braun, to Korolev, and to Utkin.

Rocket development was a "splash" in history. Nuclear arms in the United States and in the Soviet Union resulted in creation of a weapon dangerous to all mankind, one capable of destroying people. The euphoria of conquering near and deep space passed after visiting the Moon. As things turned out, the benefits from that visit were less than the expenses of traveling there. The paradox of the 20th century, therefore, is liquidation of the powerful military rockets that were created. It is difficult now, when the rockets he created with his life's blood are going under an electric-welding knife, to present V. F. Utkin's feelings. Destruction of things people have created has taken place repeatedly in history—the Babel Tower, the burning of both Rome and Hiroshima. In history, however, it is the creators and not the men of destruction—the barbarians—who remain, and rocket designer Vladimir Fedorovich Utkin's individual personality will remain forever in human memory.

V. F. Utkin in Our Memory

"Great ones see from afar." These words of a poet make clearer and clearer sense in connection with V. F. Utkin. People often do not appreciate an individual's unique qualities in the present. Only in due course, when we begin to assess an individual's actions, do contours of greatness appear more clearly and an understanding of his true stature emerge. The first external impression about V. F. Utkin was deceptive: he did not immediately stand out from the crowd. But getting to know Vladimir Fedorovich over time exposed this individual's truly talented Slavic soul.

I recollect one of V. F. Utkin's first trips abroad. It was the World Space Congress of 1992 in Washington. Vladimir Fedorovich was asked to present in English at the Congress his report on space debris. The report was received well, despite a certain tension among representatives of the former Soviet Union. At once Walter Flury approached and asked for the text of the report. He subsequently became the authority on space pollution and sent new universal reports almost every year. The Congress organized a reception on the estate of U.S. President G. Washington [Ed.: Mount Vernon]. We went there not by bus, but by steamship on the Potomac. Financing of foreign trips was very modest then, worse than in Soviet times, and we could not to pay for the steamship ticket, but

Michael Yarymovich, vice president of the International Academy of Astronautics, transferred his tickets to us).

During the four hours it took the ship to steam to the estate, we had an opportunity to associate with the American scientists and industrialists who were also passengers. When information on V. F. Utkin's presence was distributed, a pilgrimage to us literally began: those acquainted and unfamiliar were approaching and asking to meet with Vladimir Fedorovich. Presidents and vice presidents of the largest space-rocket companies of the United States were presenting themselves and started interesting, tense, valid conversations. For Americans, V. F. Utkin was one of their main intellectual "opponents." Inaccessible for decades, he now was the focus of genuine interest. During other meetings at the Congress, despite the linguistic barrier, everyone obviously recognized V. F. Utkin's authority.

Then there were meetings at the International Astronautical Congresses in Jerusalem [Israel], in Turin [Italy], and at a symposium on space science and technologies in Gifu [Japan]. For me, dialogue with Vladimir Fedorovich was an enormous school of life. In the new conditions after the collapse of the Soviet Union the necessity for sincere, frank advice was felt especially sharply. I remember well our long conversation in Turin on the enormous area in front of the palace of congresses where we spoke about events in Ukraine and Russia, not having another soul within 100 meters. To this day, I regret that such a conversation occurred so late.

Vladimir Fedorovich's intelligence and authority before the world community successfully allowed him to head a number of significant international and Russian commissions, including the "Stafford–Utkin" Commission.

Some research workers frequently voice a skeptical attitude about the scientific degrees received by the main designers. There are a lot of skeptics in relation to designers because, for some reason, deciding what to draw is not considered scientific work. Skeptics do not take into account that a main-designer position is a scientific post, that each decision by the main designer demands a many-sided scientific analysis. It demands something greater than knowledge about this or that; it demands not only scientific and technological expertise but also knowledge about economy, policy, and manufacturing organization. Vladimir Fedorovich was a designer, and the skeptical attitude regarding the list of his outline sketches of concrete rockets, also touched him to a certain degree. Many do not know, however, that in the monographs issued with his participation, his contribution was not as chief. I recollect our first monograph "Valves in Onboard Systems of Long-Range Missiles and Spacecraft" (editor M. Jangele, co-authors S. Titov, L. Nazarova, V. Prisniakov et al.), which in many respects generalized results of design-department work headed earlier by Vladimir Fedorovich. His rigid requirements for the written material lifted the monograph to such a level, that it still remains the reference book of designers. Or take our other monograph, "Dynamics of SPRM" (V. F. Prisniakov, 1984), issued under academician V. F. Utkin's editorship. I recollect Vladimir Fedorovich's remarks, which essentially improved the book. It is necessary to say that he did not accept any proposal to be co-author of the article or of the organization's report.

In Dnepropetrovsk University we were carrying out big work on the creation of nuclear turbo-machine converters and electric propulsion. Vladimir Fedorovich was interested in these projects. He visited our laboratories more often than other DBYu leaders, and this allowed us for many years to bypass other organizations.

I had the luck to witness the high regard for him by such outstanding scientists as academicians J. B. Hariton, E. A. Negin (founders of a nuclear shield of Soviet Union), V. S. Avduevsky, and A. N. Guz. Vladimir Fedorovich was an indisputable authority at the mechanics branch of the National Academy of Sciences (NAS) of Ukraine.

Vladimir Fedorovich's strategic thinking, the deep state approach to the decision of tasks, and ability to think 10 steps ahead were always amazing to me. Natural peasant cunning, the life experience of youth acquired during four years of war, and his skill at finding allies and friends everywhere allowed DBYu's table to be crammed with jobs. There was a saying among militarians during the times of Korolev-Yangel: "Korolev works on TASS, and Yangel works on us." That changed in Utkin's time at DBYu to "Utkin works on us and on TASS."

Concentrated acknowledgment to this materialized in four generations of rocket systems—from ampoulization of refueling for rockets, to "mortar" launching, to railway-launched rockets, to the most powerful rocket "Satan" and the most important rocket "Zenit," a symbol of our "entry" into the 21st century (it is considered, that mankind in the 19th century was transported by a steamship, in the 20th by a train). Unfortunately, followers of Vladimir Fedorovich have failed to take full advantage of the enormous scientific and technical potential of rocket engineering. It is impossible to blame them, however, because according to director Yuzhmash A. M. Makarov, "Time has demanded such people." But it is obvious, that academician V. F. Utkin's personality towered among many other outstanding designers.

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