History of Rocketry and Astronautics

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Front Cover Illustration:

Gleb E. Lozino-Lozinsky (1909–2001). Originally an aircraft designer of MIG fighters. Later Main Designer of spaceplane concepts at NPO Molniya. He was the Person who constructed the spacecraft "Buran," the Soviet spaceplane. General Designer of NPO Molniay.

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Chapter 1

The 100th Anniversary of the Birthday of the Designer of Space Planes, Gleb Lozino-Lozinskiy*

Vladimir F. Prisniakov† and Vladimir A. Zadontsev‡

Abstract

This chapter presents a review of the activity of Gleb Lozino-Lozinskiy, the founder of Soviet aerospace systems, whose life was connected closely with Ukraine. It tells about him, both during his life in Ukraine and his work at the Mikoyan Design Bureau, being chief of a brigade participating in designing the engines of the I-250/MiG-13 and MiG-17 jet fighters, deputy main designer of the MiG-21, then main designer of the Spiral aerospace system and the MiG-31. The report gives special attention to Lozino-Lozinskiy's 25 years of activity as the general designer of NPO Molniya, where he developed the orbital ship Buran, the business aircraft Molniya-1, and made the projects of aircraft Molniya-100, 300, 400, 1000 (Herakles) and the reusable multipurpose aerospace system (MAKS). The domestic press had written much about Lozino-Lozinskiy. In the foreign scientific literature, his creativity was reflected much less. Authors in the

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West were acquainted with little-known materials about the life and activity of this outstanding designer. The purpose of the chapter is to inform the world community about him and to analyze from a scientific and technical point of view his achievements, which have not lost their relevance and can help many scientists and designers in designing orbital and aerospace systems.

Introduction

Many founders of Soviet space-rocket systems have been connected closely with Ukraine. They were born and studied in Ukraine, or they arrived and worked in Ukraine in the space-rocket industry. Among this constellation of names (including Y. Kondratyuk, S. Korolev, V. Glushko, M. Yangel, V. Chelomey, V. Utkin, M. Reshetnev, A. Lyulka, V. Boudnik, V. Kovtunenko, G. Kisunko, V. Dogoujiev, L. Smirnov, A. Makarov, V. Voznyuk, G. Langemak, I. Gvay, Y. Semenov, I. Ivanov, A. Nedayvoda, N. Gerasyuta, B. Gubanov, V. Saygak, A. Kostikov, O. Antonov, I. Sikorsky, A. Ivchenko), Gleb Evgeniyevich Lozino-Lozinskiy occupies a worthy place. He was born 100 years ago in Kiev. He studied, worked, and gained experience designing piston engines, gas-turbine engines, and combined aviation engines in the Kharkov aviation institute. He was a witness of the October revolution and the civil war in Ukraine. He went through cholera, the famine of 1933, the Second World War, disintegration of the Soviet Union (but only to the beginning of perestroika), and he had an opportunity to go abroad.

His life was an example of high morals and inflexibility during a totalitarian regime. But details of his life were confidential for a long time. Therefore, the world space public knew about his super-progressive systems and designs, rather than about his life and creativity. This chapter fills a blank in the history of world space technology. We do not pretend to present new materials about this outstanding designer. Our information is taken from sources accessible to all. Our purpose is to present this International Academy of Astronautics (IAA) history symposium with a portrait of this academician on the centennial of his birth.

Ukrainian Background of the Founder of Aerospace Systems

Originally a nobleman, Gleb Evgeniyevich Lozino-Lozinskiy was born in Kiev on 25 December 1909 in the Julian calendar (7 January 1910 in the Gregorian calendar) in a barrister's family. All orthodox celebrate Christmas this day. For a long period of time after the revolution, there were two calendars in

Ukraine, and people born in imperial Russia adhered to the Julian one for a long time.* Therefore, this date of birth was left in documents about Lozino-Lozinskiy, and it is written on his gravestone.

With the lapse of time, the family moved to Kremenchug, a small Ukrainian town on the river Dnepr, nearby Poltava, where eight-year- old Gleb faced class struggle for the first time (it was during the October Revolution and civil war in Russia). There were the first lessons of "revolutionary justice" in children's memoirs of Gleb. First, his family was thrown out of its own five-room apartment; they had to move to a flat that was smaller, where they could not fall asleep the first night because there were lots of lice. After that, the family was compelled to move to another flat with two rooms [1].

Figure 1–1: Gleb Evgeniyevich Lozino-Lozinskiy
(7 January 1910 – 28 November 2001).

Lozino-Lozinskiy obtained his education, in all subjects, thanks to his father, and owing to civil war, when the authority in the city changed almost every week according to colors of the rainbow—"green," "red," "white," "dark blue." There was an authority of anarchists, and N. Mahno proclaimed the first racist slogan: "we shall beat red until they become white, and white until they become red . . ." Through such life, Gleb learned to adapt to constantly changing conditions, to a cold existence without food. Certainly, it was difficult for the 10-year-old boy to understand why there was nothing to eat except the oilcake "makuha" (the remainder of sunflower seeds after squeezing out the oil). It was difficult to discern the truth from official information. He reminisced: "Later, in Kharkov, I

* It is necessary to notice that until now, in Ukraine, the new year is celebrated twice: on 1 January (Julien) and on 14 January (Gregorian).

saw how people in the streets who fell and died from exhaustion; in 1933, there was famine in Ukraine. I trusted and thought that these people were starving because they didn't want to help the government, and that is why they buried bread in the ground." After the end of civil war, it became possible to continue his education at school, and Gleb went to the seventh and last class of labor school.

It is difficult now to understand the thoughts of this nobleman, who was obliged to study in technical school to obtain a specialty of metalworker, instead of entering Russian or European universities. It is possible just to imagine the condition of the young man, compelled to suffer privations "because of revolutionary necessity" and to feel injustice for a long time. That the USSR Academy of Sciences did not elect the distinguished designer as its member (Russia limited his membership in "trade-union" academies) shows that his nobility by birth did not play a final role.

Studying in a technical training college entitled him to enter the university. The locksmith-nobleman G. Lozino-Lozinskiy, foreseeing there would be a time when technical experts would become necessary, entered the faculty of steam-power units in Kharkov mechanic-engineering institute (KhMMI) in 1926. All his life, Lozino-Lozinskiy displayed an interest in power machines, engines (first steam-power, then air-breathing), and then rockets. On 20 December 1930, he graduated from the institute with engineer-mechanics qualification in the "vapor technology" specialty and went to work as an engineer-calculator at Kharkov Turbine Generator Installations Factory (KhTGZ). Experience in designing the first domestic steam condensation high-power turbines (50 thousand Kw) was the main reason for his transferring to aviation. "It was not just an accident," Lozino-Lozinskiy said, "It was a conformity, because experts on turbines were much closer to aviation and rocket engines, in as much as turbines are a component of these engines." Therefore, they were a source for updating engineers on the engines of flying devices. Young expert Lozino-Lozinskiy quickly gained authority among his colleagues and, as the author of a new design procedure for turbines, was invited to teach qualification improvement courses.

The beginning of Lozino-Lozinskiy's activity was in Kharkov Aviation Institute (KhAI), where he had worked since January 1932, holding a post of engineer of the scientific-test station of the propulsion engineering department (managing professor V. T. Tsvetkov). The principal reason for this invitation to work at KhAI was his participation in creation of a steam-power installation (PT-1) of unprecedented capacity for those times (3,000 hp) for the heavy bomber projected by Andrey N. Tupolev (ANT-42/TB-7) [1].

In its preliminary years, KhAI became the practical center for scientific and technical development, where Lozino-Lozinskiy and A. Lyulka started their activity. Global progress needed the mobility of people. Military authorities requested new kinds of weapons for destruction of enemy forces. The existing automobile, railway, and sea transports did not satisfy requests for increasing speed. This global transport crisis in the field of technical equipment requested creation of essentially new kinds of transport.

As is known from the theory of accidents, if a system passes a point of bifurcation, an exit from it can be either structural or system reorganization. Such an exit for world transport technique became aviation and rocketry. Germs of progress for new transport, certainly, appeared in many countries. In the Soviet Union, the leader became Kharkov, capital of Ukraine at that time, with its powerful mechanical engineering and enormous scientific and technical potential. The main problem for aviation, which was increasing speeds of flight promptly, was an inefficiency of transformation of the rotary movement of the air screw into forward motion of the plane close to the speed of sound. Increasing the speeds of flight demanded even greater augmentation of capacities and mass of engines that transformed the plane into a flying device, that enabled carrying the heavy piston engine. Therefore, all over the world, there was an intensive search for an alternative to the screw and the piston engine. Frequently, the direction was deadlock, but that is how progress develops. Frequently, there were futuristic developments and ideas (for example, the electro-rocket engine, which was developed in Odessa by V. P. Glushko, or liquid rocket engines for gliders and planes).*

Remarkably, the Kharkov aviation institute was on the edge of progressive ideas. In 1932, Scientific-Researching Sector (SRS) of KhAI got a task to study using a vapor turbine variant for installation on Tupolev's bomber. During this work, there were some changes in Lozino-Lozinskiy's position: first, he was senior engineer; then, from 1937, deputy chief of KhAI's bureau of preliminary designing. After four years of work, young engineers G. E. Lozino-Lozinskiy, A. M. Lyulka, and M. E. Gindes came to the conclusion, on the basis of theoretical research and experiments, that application of steam-power installation on the plane was inexpedient, and they offered two variants of a new engine [3].

While designing the steam turbine for Tupolev's bomber, Lozino-Lozinskiy, aspiring to reduce condenser sizes, offered the solution of using a fan. At that time, this idea was not useful, but in 10 years, it completely justified itself when the world's first afterburner, designed by Lozino-Lozinskiy, was installed

* Possibly, if the preference at that time had started to be given to air-breathing (giving to rocket engines only flight in a vacuum), instead of LPRE and SPRM for the first stages of rockets, all development of rocketry might have been accomplished with more economy and more sparing of the environment.

on the piston engine of a I-250/MiG-13 high-speed fighter plane. This afterburner created the jet force additional to the thrust of the screw, which allowed the plane's speed to increase from 150 km/hour to 850 km/hour [6].

In 1937, young experts developed the first domestic gas-turbine engine, (GTE) RTD-1, designed by student A. P. Eryomenko (later, became rector of KhAI), for jet fighter KhAI-2. Working in Kharkov, Lozino-Lozinskiy was co-operating with the future outstanding designer of aerospace engines Lyulka and engineer Gindes. This period was rich in original ideas. Together, they designed a small steam-power installation working on a piston engine's exhaust gases, then proved the possibility of creating a GTE, thereby laying the foundation of a new era in aviation development [3].

In the middle of 1939, destiny made "the Leningrad zigzag" in Lozino-Lozinskiy's life. He transferred to Central Boiler Turbine Institute (CBTI) where, together with Lyulka, he studied the project of a plane power-plant with piston engine and afterburner duct [3], and they worked on different variants of jet GTEs. Obviously, the engineer was noticed by appropriate Soviet management. In the beginning of 1941, Lozino-Lozinskiy was transferred back to Kiev, pursuant to a request from the first chief of the special design bureau of plant No. 43 (the plant's main designer was V. K. Tairov). Under a completely confidential order of People's commissariat of aviation industry N115/ss, he was appointed chief of thermal group N5. In Kiev, he continued working on creation of the plane with the combined engine. Lozino-Lozinskiy had not worked on this prospective theme for long when the Second World War began. The war compelled his evacuation to Kuibyshev, where he met people evacuated from Mikoyan Design Bureau (plant No. 155) in Moscow. He had not worked there long, when the plant's design office and development workshops returned to Moscow in April 1942. According to decision SDC No. 1436, Lozino-Lozinskiy was officially transferred to plant No. 155 as senior engineer. He was 33 years old, the age of Jesus. Ukraine had prepared and given Moscow the talented engineer, who possessed inclinations to become an outstanding designer. There was an informative and professional "Moscow" period in Lozino-Lozinskiy's life.

Lozino-Lozinskiy as the Aircraft Designer

During the Second World War, senior engineer Lozino-Lozinskiy worked on an introduction of his old idea of using an afterburner in the structure of the piston engine. The afterburner he first developed was installed on the I-250 skilled, high-speed fighter plane with piston engine VK-107A. The project was successful and allowed the new plane's speed to increase almost by a quarter.

This plane, which received the serial name MiG-13, was produced in February 1945.

After the end of the war, destiny again made a short-term zigzag in Lozino-Lozinskiy's life: with the rank of major, he went to Germany to adopt technologies and trophy jet engines, the JUMO and BMW. Of course, such a trip gave the competent engineer huge advantages.

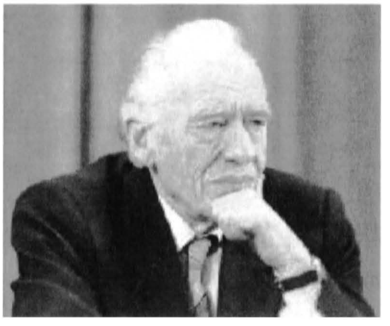

Figure 1–2: Gleb Evgeniyevich Lozino-Lozinskiy.

At Mikoyan Design Bureau, Lozino-Lozinskiy continued development of projects on different variants of jet gas-turbine engines, including combined engines (the piston engine and aerojet engine), concentrating his attention on increasing power efficiency of the plane's engines. This project became most important for him. Nowadays, the design and operation of the afterburner can seem simple. But take into consideration that it is an intermediate link in transformation to the turbojet (TD).

Figure 1–3: MiG-29.

Figure 1–4: MiG-31.

The process of cooling the afterburner is simple, but during the creation of its adjustable critical section, it was necessary to solve very serious problems. Development of the afterburner duct essentially speeded up the creation of turbojets suitable for installation on a plane, thanks to obtained design experience and to resolution of scientific problems. Success with the MiG-13 allowed installation of an afterburner on a serial fighter, MiG-15 (15,560 units of these planes in 19 versions), which reached the speed of sound for the first time in the Soviet Union on 18 October 1949 in a flat dive and on a MiG-17 (11,000 units in 14 versions) fighter on 1 February 1950, with the speed increased almost three times due to the afterburner duct. For the first time in the Soviet Union, the sound speed was exceeded even during horizontal flight.

The main problem given to Lozino-Lozinskiy this time was creation of an optimal design for the complex interface of an engine with air inlet and afterburner duct. Solution allowed creation of the first-ever serial supersonic fighter, the MiG-19, and the best fighter of that time, the MiG-21, with maximal maximum speed of Mach 2, equipped with a frontal adjustable supersonic air inlet. There were two absolute world speed records in horizontal flight in 1959–1960 and an absolute world altitude record in 1961 on the account of the E-66 version of the MiG-21 [6]. All these successes in creation of a new generation of planes provided overwhelming superiority to fighters of the MiG type (MiG-15, 17, 19, and 21) in postwar local conflicts (the average ratio of losses in Vietnam between Soviet and American-made fighters, with the benefit of the MiG-21, during the period from 1966 to 1970, was 3.1:1) [6].

Lozino-Lozinskiy directly took part in creation of the MiG-29 frontline fighter, that was considered one of the best fourth generation fighters. Today, MiG-29 fighters are in service in more that 20 countries. It is unique, that it is being used in Germany, a member of NATO, because of its characteristics. At the end of 1993 more than 1,000 planes had been produced [1,6].

The MiG-31 supersonic interceptor was created by Lozino-Lozinskiy, as the main designer, his having been appointed to that rank in 1971 [3]. This plane was intended for use in the country's air defense system through practically all types of attack and in any weather conditions. With identical efficiency, it operated at both subsonic and supersonic speeds and was capable of striking some enemy planes from a distance of 200 km. At the beginning of 1992, there were about 250 MiG-31 fighter-interceptors serving in the air forces of other Commonwealth of Independent States (CIS) countries. The MiG-31 was the first serial fighter with phased array radar (the most powerful in the world). A group of four cooperating MiG-31 planes can supervise an air space with frontal length from 800 to 900 km [6].

Lozino-Lozinskiy as the Designer of Aerospace Systems

During the time before the Second World War, all attention was directed to creation of planes for various purposes. The rocket was considered as future business, where visionaries were engaged. The truth of the matter is that small rockets, showing their efficiency in destruction of enemy forces, were created in the Soviet Union during those years. During the war, Adolf Hitler's Germany began to lose air superiority and to search for ways of hitting large targets from a long distance. So, the need to use ballistic missiles created by Wernher von Braun appeared. It did not bring decisive success, but this new kind of weapon made the most serious impression on allies, both in the West and in the East. Therefore, at the end of the war, all rocket development and all German experts were transferred to the United States and the Soviet Union. It became a pulse for extremely fast development of the aircraft's "ugly duckling." The rocket quickly pressed aircraft in many military areas (sometimes unduly and short-sighted). The aircraft also increased speeds, began to approach space speeds, and to apply for access to space. In the Soviet Union, it was necessary to solve a challenge: what should be the preference, strategic bombers, intercontinental winged or ballistic missiles? Development of aircraft or space-rockets? [4]

In the early 1960s in the United States, the first flights of the X-15 experimental rocket aircraft began with a speed above Mach 6.5 and an altitude up to 11 km.* The flight of Yuri A. Gagarin, the first person to space in 1961, the beginning of the militarization of space, and the possibility of "star wars" set the agenda for creation of a space plane capable of starting to leave for space from any place, to maneuver, find enemy objects, destroy them, and return to Earth, such as an airplane. The main advantage should be the possibility of multiple uses for the elements of such a system. Therefore, in 1965, practical work on winged astronautics was given to Mikoyan Design Bureau 155.†

The problem consisted in development of an aerospace system consisting of a hypersonic accelerator aircraft (HAA) and a man-rated, single-seated orbital plane (OP) with rocket accelerator. The OP could be used as the scout, the interceptor, or the shock plane with an "Orbit Earth" class rocket and could be used for inspection of space objects. Horizontal start of the system was provided by an acceleration trolley. Separation of the OP and building up of speed were realized with the help of rocket engines. The ability to make an aerodynamic maneuver for descent on a planned trajectory in an atmosphere was set with a range up to 6,000 km and with a lateral error up to 1,500 km. The OP should have landed at an airport with a speed of 250 km/h.

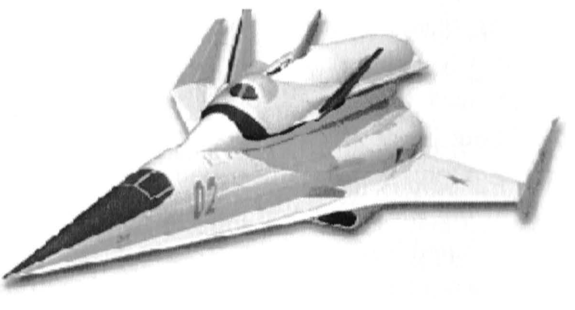

Figure 1–5: The orbital plane.

* The X-15 project was carefully studied in the Soviet Union within the framework of spent similar works: outstripped the time and finished up to flight tests at the end of the 1950s projects of intercontinental, winged, high-altitude rockets (cruise missiles) Burya and Buran (it is not yet that Buran) with direct-flow engines and at the creation of high-altitude, antiaircraft missiles in the middle of the 1960s.

† Skilled development of winged spacecraft was conducted practically in all the country's serious aviation and space KBs (S. P. Korolev's SDB, V. M. Myasishchev's SDB-23, V. N. Chelomey's SDB-52, and A. N. Tupolev's SDB), but all of them provided traditional rocket launching and did not promote further outline study.

Lozino-Lozinskiy was appointed as the main designer of the prospective aerospace system named Spiral (system 50–50). According to the plan, dated 29 June 1966, the project included development of a 115 ton system consisting of three elements: the 52 ton HAA reusable, hypersonic, air-breathing launch aircraft (length of 38 m, span 16.5 m); the expendable two-stage rocket booster (RB); and the OP manned orbital aerospace-plane. The launch aircraft, with engines burning oxygen and hydrogen, would accelerate the whole system to a hypersonic speed of M=6 (about 2 km/s), releasing the RB and OP at an altitude of 28–30 km. The RB, mated to the OP, consisted of fuel tanks with fluor, or oxygen and hydrogen, and liquid rocket engines (four on the first stage and one on the second stage, each with 25 tons thrust) developed by Glushko. The RB was separated and fell into the ocean after putting the OP in the planned point. The range of orbital altitudes was from a minimum of 200 km to a maximum of 600 km.

Using the HAA required some answers for serious problems. A team of engineers under Lozino-Lozinskiy's management made numerous bleeding operations of the vehicle in a wind tunnel and found answers that proved calculations for all questions [1]. Lozino-Lozinskiy offered a very graceful solution to a design for the OP (the second step of Spiral). It was almost the same as the usual tiny fighter, but it also was capable of working in space with greater efficiency and of entering any orbits, which gave it a big advantage over massive shuttles [1]. Really, it is necessary to agree with the author's opinion [1] that Spiral was a project 50 years ahead of its time.

Unfortunately, lunar landing rivalries between the Soviet Union and the United States and financial possibilities compelled scaling down this work. "We are not going to be engaged in imagination," declared defense minister Marshal Andrei Grechko [1]. The Spiral program was terminated despite more than 75 million rubles having been spent, and its having surpassed all parameters of Dyna-Soar, the American aerospace system competitor.

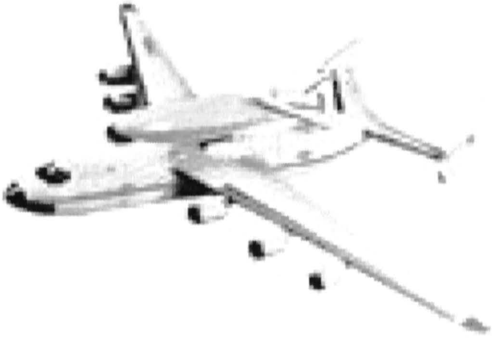

Figure 1–6: Spiral in flight.

In the Soviet Union, it was decided to create the Energia-Buran system as an adequate answer for the American Space Shuttle. But, the results obtained by Lozino-Lozinskiy's team laid the foundation for development of the Buran airplane and for studying a hypersonic passenger plane with 100 seats and a flight range up to 10,000 km [1]. Later, Lozino-Lozinskiy suggested the realization of a modernized Spiral project, where a super-heavy carrier airplane, the An-225 Mriya, would be used instead of a hypersonic vehicle [1].

First, the start of a new Spiral airplane would cost a minimum of 10 times cheaper than the rocket version, because the aerospace system would lose an outboard tank in flight and Buran used an expensive rocket. In addition, it was necessary to use complex engineering constructions for take-off and landing of the Space Shuttle, but for the start of a subsonic accelerator-aircraft, it was possible to use existing air stations after making some renovations.

Second, Buran needed areas where the exhaust rocket stages must be thrown down. These areas dictated a direction from which Buran could start. But, the orbital airplane did not need areas; therefore, it had complete freedom in choosing flight trajectories.

Third, Spiral was incomparable to Buran in efficiency. To place Buran into one or another orbit, it was necessary to wait, when Earth turned, so that starting from a space center, a ship would get into the necessary orbit. Then, starting the orbital maneuvering engines, the pilot would be able to fly to the space object. And, the orbital plane had no need to spend time on expectation: Mriya would bring it to the necessary place to reach the right orbit. If it had not been for the results from Spiral research, the Buran project would not have been so fast and successful.* Molniya Scientific Production Association, also known as NPO Molniya, was created on the basis of design bureau (DB) Molniya and DB Burevestnik in 1976 to develop Buran. Lozino-Lozinskiy was appointed as general director and main designer [1,3].

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* One can note that the EMFP (Experimental Manned orbital Flying Plane) was a system realized under the name BOR (pilotless orbital spaceplane) and executed in scales of 1:3 (BOR-1, BOR-2) and 1:2 (BOR-3, BOR-4) that were tested in the middle of the 1970s, which enabled checking out many elements of the OP design. BOR-4 represented the pilotless device with a length of 3.4 m, a wingspan of 2.6 m, and a mass of 1,074 kg in orbit and 795 kg after returning. During the period 1982–1984, four BOR-4 devices were successfully launched by space rockets, after which they landed (two in the Pacific Ocean and two in the Black Sea) with the help of a parachute. Subsequently, by the technique fulfilled on device BOR-4, five suborbital starts of the device BOR-5, representing a scale model (M1:8) of Buran with an approximate mass of 1.4 tons, were carried out between 1984 and 1988, for research on aerodynamic characteristics and conditions of reentry to the atmosphere.

Development of the Spacecraft Buran

In 1972, U.S. designers officially began working on the reusable Space Shuttle vehicle project with an expressed military orientation. There were not only supporters, but also opponents of this idea. The basic argument against it involved placing into orbit not only a useful, disposable load, but the plane itself, with a mass two to three times more than the disposable load. But sometimes political reasons are more important than technical and economic reasons. And in this case such a reason made it possible for the easy transformation of this vehicle into a space bomber capable of delivering nuclear attacks from space.

The Soviet government realized, that in response to the U.S. project, only Lozino-Lozinskiy, with his unique operational experience, could make the same system. On 12 February 1976, the Soviet government published Decision Number 132-51.

> About construction of a reusable space system with structure of a booster stage, the orbital plane, the orbital transfer vehicle, a system control complex, start-landing and maintenance—reducing complexes and the other ground facilities providing insertion into northeast orbits (height 200 km) of payloads (weight up to 30 tons and returning from an orbit payloads (weight up to 20 tons). [6,7]

NPO Molniya was formed from two design bureaus on the territory of the Tushino plant and DB Myasishchev. The majority sincerely did not believe the Energia-Buran would succeed, first of all because of the impossibility of creating a pilotless, completely automated orbital vehicle. This last factor needed a high level of development of computer technologies, that Lozino-Lozinskiy thought were in the initial period in the Soviet Union [5].

Figure 1–7: SPA Molniya.

Leading specialists, who had been working on the Spiral project, came to NPO Molniya from the DB Zenit of A. I. Mikoyan and DB Raduga; experts from DB Salyut, DB Energia, and other rocket and aviation organizations were invited. There were more than 250 doctors and candidates of science. Structurally, this vehicle was constructed under the airplane scheme with a triangular (delta), double variable-swept wing and unusually small elongation of the fuselage. There were aerodynamic direction controllers and elevons that allowed lateral maneuvering up to 2,000 km during flight in the atmosphere. The length of Buran was more than 36 m; its span about 24 m, its height more than 16 m, and its weight before start about 105 tons and 82 tons after landing. There was a hermetic cabin for two to four crewmembers and up to six passengers (researchers) in the nose of the fuselage. About 30 tons of useful loading were delivered to orbit in a cargo bay. There were two groups of engines combined in one installation for maneuvering in space (engine combustion components were oxygen and hydrocarbon fuel). The prudent limit of endurance was about one week, but it was possible to stretch the flight duration to one month). Thermal protections covering Buran consisted of 38,000 heatproof tiles, capable of withstanding temperatures up to 1,300°C. Wing and fuselage leading edges were made of a carbon–carbon composite material meant for temperatures up to 1,650°C [7]. The glider was made in the Tushino plant.

The first flight took place on 15 November 1988 in bad weather conditions. The vehicle separated from the central block and entered orbit with a conditional altitude of 11.2 km perigee, and 154.2 km apogee. Its engines had given out adjusting pulses in apogee, after which the vehicle appeared in an orbit with altitude about 255 km. While on orbit, all systems were working normally. The retro burn that provided a normal entrance into the atmosphere occurred after two incomplete orbits. Temperature in the nose of the fuselage was 907°C, and 924°C on the leading edge of the wing. Landing speed (touchdown speed) of Buran was 260 km/h, so the path length was 1,620 m. The program of the first flight was completely and successfully executed. Lozino-Lozinskiy recollects:

> Buran is a grandiose épopée and a huge step forward in the field of creation of space vehicles. Contrary to many points of view, I would like to emphasize that V. Glushko's decision on clear task sharing between the booster and Buran was true. By means of it, there are two independent products in system Energia-Buran: the first one is a powerful booster capable of placing the vehicle and other payloads into orbit; the second is the space plane. The fully-automated Buran is a very important step in the development of future transport space systems. ...
>
> Now, with the help of obtained experience, it is possible to build multiple, high-efficiency, multifunction vehicles. An integrated control and diagnos-

tic system also confirmed its reliable work during the first start of Buran. ... During deorbit there is heating up of the hardware's external surface to 1,500°C and speed varies from 27,000 km/hour to landing speed of 300 km/hour. There were two admirable points that surprised foreign experts when I traveled to foreign countries to lecture about development of Buran. First of all, they never assumed that Russia could organize and coordinate the work of more than 1,000 enterprises and accessory manufacturers, or that all previous works and the triumphal start-up of Buran would occur without failures. Secondly, they were impressed by Buran's fully automatic system, which provided unmanned landing. [5]

Figure 1–8: Mriya with Buran.

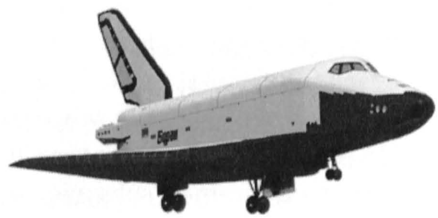

Figure 1–9: Buran in flight.

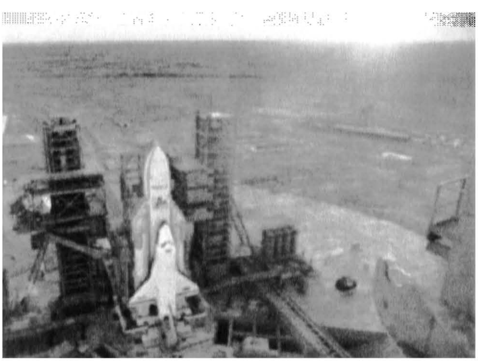

Figure 1–10: System Energia-Buran on start.

Figure 1–11: Landing of Buran.

After Buran—Molniya, MAKS, and Heracles

Life did not stop for Lozino-Lozinskiy and his organization after the end of the Spiral and Buran projects, which had become unnecessary in new geopolitical conditions. Probably, for lots of people who were capable of looking forward, such a destiny was an ordinary way for time to overtake many projects. Most likely, it was not the result of the natural historical process of progress, but it was rather the result of irrational man's baseless or unconsidered interference with this process. In the 20th century, such a frequent intervention happened because of the two opposing sides in the Cold War. The sides did not give priorities to global progress or the creation of something, but they gave it to individual tactical events, presupposing that the prospect of general destruction would spark "terror" in public opinion.

Certainly, a person like Lozino-Lozinskiy looked far forward, and at the end of the 1980s, he started to develop a reusable multipurpose aerospace system (MAKS) using a super-heavy transport plane, An-225 Mriya, as a launcher. This project provided a much lower cost for placing payloads into orbit, a possibility of starting in any direction and returning payloads, multiple uses, and ecological cleanness. According to scientists' opinions, this project was one of the most promising on the path toward further space exploration. Actually, it represents an updating of Spiral in the technical and political context of today's reality. According to Lozino-Lozinskiy, replacement of the still nonexistent super-complex HAA with a simple rocket accelerator on the start of an orbital plane (manned or unmanned) from a subsonic plane—spaceport An-225 Mriya determined the prospect of developing future transport systems capable of carrying payloads weighing up to 10 tons into orbit [1].

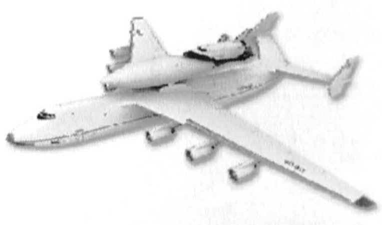

Figure 1–12: MAKC.

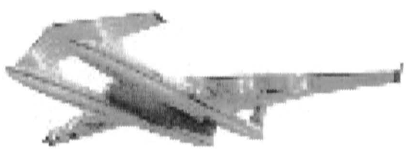

Figure 1–13: Heracles.

Figure 1–14: Plane, triplane, Molniya-1.

Figure 1–15: Variant of MASS MAKE.

One of the most difficult processes of MAKS was reliable maintenance of the dynamic separation of the second stage (OP with a fuel tank, with a total mass of 275 tons at launch) from the first stage (launching aircraft An-225, with a take-off mass of 620 tons). A successful solution to this problem was determined by the experience of developing and successfully realizing the automated monitoring system of Buran's condition, which allowed construction of the flying launch area on the Mriya plane developed in Kiev by O. Antonov's DB [5]. It radically changed points of view and possible systems for inserting a vehicle into orbit. Besides, after the acceleration of OP, it was necessary to jettison an external tank before entering an orbit. The OP's own propulsion pack was the substantial advantage of MAKS. Such an engine already existed: it was the three-component RD-701 cruise engine developed by NPO EnergoMash. There were two single-chambered RD-704 engines at the bottom of it. It worked simultaneously on oxygen, kerosene (first mode), or hydrogen (second). The thrust of the RD-704 was 204 and 81 tons respectively. The second stage had four unified versions with various payloads, various working orbits and flight duration, in a manned or unmanned vehicle. The Mriya and orbital plane MAKS system provided launching of the aircraft in a plane strictly coplanar with the plane of an orbital station, and due to this, the coupling was possible in two to three hours. This condition becomes crucial in the case of rescuing a station's crew. Such a system for launching into an orbit allowed optimizing start-up parameters, practicing equatorial start, and controlling the start of other systems from the equator. This system allowed delivery of four to five tons of payload into geostationary orbit. There were characteristics for multiple uses of systems: the launching aircraft up to 1,000 times; the OP up to 100; liquid propellant rocket engines (LPRE) up to 15 times; and an external tank once. The system provided a launch cost of less than $1,000/kg. It was 15 times better than the Space Shuttle. With the necessary level of financing, a complete construction cycle was two to three years [6,7].

In addition to MAKS, NPO Molniya develops projects of small multipurpose planes Aist-2, Molniya, a group of triplanes (the Molniya-1 taxi for six passengers; the Hercules super-heavy craft capable of carrying up to 500 tons) that are the greatest design achievements in aviation and aerospace techniques. Among these projects, the Molniya-1 triplane, with flexible wings during transportation and a pusher screw fixed behind, has caused unexpected interest! The speed of Molniya (this plane already has passed flight tests) is 450 km/h and its flying range is 4,000 km; gasoline consumption is the same as a Volga automobile. This plane was transported in a container that also could be used as a hangar [1].

All these developments strongly overtake time and frequently are perceived as imagination. But, the time for space tourism is not far off, and flight by plane is always more preferable than flight on a rocket. The time for using the nearest planets, the Moon, and asteroids for updating stocks of minerals is not far off. But, the most serious problem for Earth is mitigation of asteroid danger. Therefore, the aerospace system developed by NPO Molniya could provide flights to asteroids for the purpose of changing the trajectory of those that are coming dangerously close. The potential of Lozino-Lozinskiy's ideas is so great that we should pursue them even today.

The Designer, the Scientist, the Person

Lozino-Lozinskiy showed the qualities of a designer in KhAI, where he first stated the idea about installation of an afterburner and the fan for increasing a plane's thrust due to additional jet thrust. Actually, these ideas transformed the piston plane into a piston jet (MiG-13) that pointed to the reality of the future transformation of piston-engine aircraft into jet aircraft. Such design ideas could not be born spontaneously by a technically illiterate person, but Lozino-Lozinskiy said he frequently made important decisions that were intuitively optimum: "And when we were making Buran, I used intuition quite often when comparing a number of variants, because the volume of knowledge I had obtained was not enough to make the correct decision." Later Lozino-Lozinskiy successfully came back to the practice of using afterburner ducts in planes of different modifications, thereby solving a number of problems; in particular, he solved a problem with regulation of their cooling, which included construction of an afterburner duct with an adjustable choking section.

Completely unusual, Lozino-Lozinskiy generally used the correct perspective and method in his assessment of the design solution, in which the intuitive level frequently played a determining role. Such assessment, for him, was a feeling of harmony:

> We had a new point of view on the design of flying devices, which called for a harmonious combination—like sounds in a chord—of all the plane's components and characteristics. Some time ago, the appearance of the aircraft was determined by aerodynamics, and the power-plant "was entered" in it, but we were designing the booster, integrating power-plant and aerodynamics. Since that time, when making the decision whether to accept a flying device's scheme, or not, I give preference, without any doubts, to one that causes the sensation of harmony in me. [1]

As one of Lozino-Lozinskiy's most original and rather beautiful design decisions, it is possible to name the form of the OP, which provides steady flight across a range of speeds in conditions that included the influence of ultrahigh temperatures (about 6,000 K), from 7,500 m/sec to 70 m/sec during landing. For Buran, Lozino-Lozinskiy created unique flaps that allowed piloting by changing their camber to displace the center of pressure of aerodynamic forces in the necessary direction. Across a very wide range of speeds, this provided stability and controllability of the flying device [1].

According to the memoirs of Lozino-Lozinskiy's daughter, Irina G., he was the leader in the highbrow surroundings that were formed during the development of the super-advanced designs. Constant dialogue with people of his intellectual level, his talent as a designer, his foresight, and his enormous serviceability, conviction, and persistence on achieving the object in view provided Lozino-Lozinskiy with creative longevity, helped his self realization, and stimulated him in overcoming numerous obstacles created by those who, "considering themselves true intellectuals, scribbled denunciations of those who were more talented and cleverer than themselves and, consequently, who aroused their envy." Unfortunately, upward mobility in their careers was transforming many talented people into organizers, engaged in trifling current questions, and killing their creative spirit.

Lozino-Lozinskiy was distinguished among general designers. He was not the General Designer by virtue of his position; he was the General Designer essentially—the creator of all works, the generator of ideas, and the master of simple answers to complicated questions. Certainly, anything could be achieved through constant work. Therefore, according to his daughter's memoirs, "Usually, he came back home with a pile of the technical literature. It was his task for the days off. And, this way of life was good for him."

Lozino-Lozinskiy was one of the founders of the Russian Engineering Academy, where he headed the aerospace section, was scientific editor of *Aerospace Techniques and Technology* magazine, organizer of the International Space Congress that was held regularly in Moscow, and head of the aerospace systems sub-department in Russian State Technological University named after K. E. Tsiolkovsky (former Moscow Institute of Aviation Technology). The German Society for Aeronautics and Astronautics awarded Lozino-Lozinskiy the prestigious Eugen Sänger Medal and the Wernher von Braun prize in recognition of his major contribution globally to development of space science and techniques. Lozino-Lozinskiy regularly took part in the Congresses of the International Astronautical Federation (IAF), and he was elected as a full member of the International Academy of Astronautics (IAA), which is a consolidation of the outstanding personalities of space-rocket and aviation techniques.

Figure 1–16: During the 40th IAF Congress in Málaga, 1989.

Lozino-Lozinskiy's decency, talent, and elegance drew unordinary people toward him. His team consisted of capable and fair people who understood one another, and who talked in one language. Aggregation of those people was almost critical, and consequently, he really was happy in this surrounding. He was exemplary in every respect, from his familial behavior to non-acceptance of privileges. Lozino-Lozinskiy described an ordinary situation. When he was going back to Moscow, after evacuation, in 1942 in freight cars, he was appointed the main person on dealing of bread and "as well-conditioned, I had a place between man's and female parts." Daughter Irina G. exemplifies his decency, personal modesty, and absence of such character traits as money-making and consumerism:

> ... It was necessary for him to have things, which provided the possibility of a normal life. According to his understanding, life meant to be engaged in work and that was all... And, he did not think about clothes. ... And, when he had to go to the GDR (in 1960), it suddenly became apparent he didn't have the proper clothes to put on. It was impossible to go abroad in his usual everyday clothes. Certainly, father could use his contacts to buy something for his family. But, that was absolutely unacceptable for him. And, he did not bring anything from work—neither an eraser, nor a pencil, nor a clean piece of paper. He did not consider that it was necessary to get something for our house (in 1981, he, with "mum," moved to a two-room apartment with a living space of 32 square meters), they made an exception only for the first Soviet television. Father, as well as some of his colleagues, treated ranks and awards almost with contempt.

Journalist Batashev told about the moral basis of the life of Lozino-Lozinskiy and his family [1]:

> Lozino-Lozinskiy was not a religious person. However, when I think about him, I remember lines of the Gospel (Matthew 6:21): "Do not collect to treasures on the Earth . . . But collect treasures in the sky. . . . Because, where are your treasures, there will be your heart." The treasure belonged to the designer, was his idea, soaring into the sky, into space. Worldly possessions, that is material benefits, did not interest him.

Really, such a philosophical statement approaches a review of Lozino-Lozinskiy's life: "All great things go far away from market and glory: inventors of new values always lived far away from market and glory." [1]

But envious people, with immoral norms, for whom concepts of decency and honesty are either unclear or do not even exist at all, created problems for Lozino-Lozinskiy. There were situations when secret documents of his friends had gone missing, and Lozino-Lozinskiy had to go to Lubianka and unreasonably suffer exhausting night interrogations, and then, during elections to the USSR Academy of Science, he—the person who constructed Buran—was humiliatingly refused: M. Gorbachev said the following to Mr. Marchuk, president of the Academy of Science: "Why do you recommend second-hand old stuff? In our case, the middle age of academicians is inadmissibly high. If this Lozino-Lozinskiy really is so honored, he becomes well-known without a scientific rank. It is unnecessary to be an academician for this purpose." [1]

Figure 1–17: Gleb Evgenjevich Lozino-Lozinskiy, the great designer had hands of the conductor. Credit: E. Miranskiy.

Main designer Lozino-Lozinskiy held to his principles, not only in mutual relations with the subordinates but also with the heads, even though it frequently resulted in different collisions. According to A. Batashev, former Soviet prime minister, Ivan S. Silayev, minister of the aviation industry from 1981 until 1985, said [1]: "Lozino-Lozinskiy maintained an attitude very emphatically. He always was in an attack mode, if it is possible to say so." And, certainly sharpness and even ruthlessness, which were inherent to him, complicated his mutual relations with management. But, as the designer, he was the admitted leader. All people, including the minister of the aviation industry, considered his opinion. According to Lozino-Lozinskiy, his teacher was Artem I. Mikoyan. He worked under his auspices for 30 years, from 1941 until 1970, and he was deeply grateful for everything that Mikoyan gave him. His other teacher was the minister of the aircraft industry, Peter V. Dementyev, a brilliant head with extraordinary advanced feeling for the new [5].

Figure 1–18: G. E. Lozino-Lozinskiy reports to Minister of Defence D. F Ustinov about work under Buran, late 1970s.

Figure 1–19: One of the numerous meetings in a cabinet of the general designer. Credit: NPO Molniya.

Certainly, all of Lozino-Lozinskiy's merits, in many aspects, were determined by a reliable family base. His wife, Elena F. Lozino-Lozinskaya, was from a family of machinists and worked as an accountant. She always understood him in ordinary questions and despite the fact that it frequently resulted in inconveniences in life, she supported him. "Mother's soul was open to him. I think that lots of things reached father due to 'mum,' who had a knack to inform him about everything," recollects his daughter, Irina [1]. She was reconciling Lozino-Lozinskiy's unwillingness "to get" privileges and his modest way of life (seeing modern post-Soviet "shvonders and sharikovs")* with someone who knows nothing except for an aspiration to the "trough" and impetuous, frequently senseless, consumerism; you come to the thought that Lozino-Lozinskiy had all this due to noble blood.

Figure 1–20.

Figure 1–21.

Lozino-Lozinskiy died at 5 o'clock in the evening on 28 November 2001. There is an epigraph on his gravestone: "The Founder of a spacecraft Buran." It seems to us that a more suitable epigraph for Lozino-Lozinskiy would be: "The Person who constructed spacecraft Buran."

* "Shvonder and Sharikov" are heroes in M. Bulgakov's story "The Dog Heart" who live for satisfaction of their animal needs and use the communistic ideology to substantiate their immorality.

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