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Chapter 6

Corresponding Member of the Academy of Sciences of Ukraine: Nikolai Fedorovich Gerasyuta—Originator of Ballistics, Flight Dynamics, and Rocket Controllability Scientific School*

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Introduction

As a Doctor of Engineering Sciences, Professor, Corresponding Member of the Academy of Sciences of Ukraine, Hero of Socialist Labor, laureate of Lenin and State Prizes, Nikolai Fedorovich Gerasyuta (1919–1987), is one of the pioneers of rocketry-space technology in the Soviet Union, one of the founders of the Yuzhnoye Design Office (Yuzhnoye DO/YSDO), and originator of the Ukrainian scientific school of ballistics, flight dynamics, and rocket controllability.

N. F. Gerasyuta was Deputy Chief Designer of Yuzhnoye DO, and managed work activities of the Design–Theoretical Complex, which supported and assured through research and computing efforts, all phases in development of combat and space vehicles. These were issues related to ballistics, the dynamics of transition processes, rocket controllability, firing accuracy, aerodynamics,

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heat-mass exchange, et cetera. He was responsible for the development of a missile control system by allied organizations. In essence, he was a key theoretician and ideologist of Yuzhnoye DO. Yuzhnoye DO is one of the world's largest design and engineering scientific organizations in the development of rocketry-space technology.

Figure 6–1: Nikolai Fedorovich Gerasyuta.

Over 50 years of creative activities, YSDO conjointly with its cooperative entities, (which consisted of more than 1,000 organizations), developed four generations of combat strategic rocket systems, without any counterpart in the world, and which formed the basis of the Strategic Rocket Forces of the Soviet Union, and later of Russia; developed seven types of space launch vehicles, more than 40 types of liquid propellant engines and solid propellant motors; and orbited more than 400 spacecraft of its proprietary development. YSDO developments encompass many ingenious engineering and technological solutions that enabled implementation of perfect specimens of facilities unsurpassed in their time.

Biography

The biography of N. F. Gerasyuta is characteristic of many people of his generation. He was born on 18 December 1919 in the town of Alexandria in Ukraine. In 1936, he entered the Physics–Mathematical Department of Odessa State University, from which he graduated in June 1941. After advocacy of his

diploma work, he went to work in the military commissariat. Later on, he was sent to the front. Second Lieutenant Gerasyuta immediately realized, and it was burned into his mind, that a combat engineer/landmine layer may make a mistake only once—there will be no other opportunity. For four years, from June 1941 to May 1945, it was the war, day after day. At the outset, troops were falling back in battles, up until Stalingrad, and afterward, they were advancing toward Berlin. He not only marched but, one may say, he crawled all this way, emplaced land mines in fields, and erected crossings over the Dnieper, Vistula, and Oder rivers. The medals "For Defense of Stalingrad," "For Courage," "For the Liberation of Warsaw," the Orders of the Red Star and Patriotic War of the II degree—are his combat decorations. As a combat engineer, N. F. Gerasyuta never made a mistake. But at the age of 25, he had already become gray-haired.

In 1945, right after the end of the war, N. F. Gerasyuta was assigned to a mission to go off, at the disposal of Sergei Pavlovich Korolev, to scrutinize German rocket equipment at the works and design offices of Wernher von Braun. For this objective, there was established the Nordhausen Institute within the occupational zone of the Soviet Union. Captain Gerasyuta became, in a short time, one of the lead experts in the generation of scientific reports on rocket flight dynamics. In 1947, after demobilization, N. F. Gerasyuta worked in the vicinity of Moscow at the design office of S. P. Korolev, who was the Chief Designer of space and combat vehicles. The primary focus of the engineering and scientific activities of N. F. Gerasyuta became ballistic rocket flight dynamics. In coauthorship with A. G. Pilyutik, he published the first book on long-range ballistic missile flight dynamics, and in 1951 he successfully advocated his Ph.D. thesis.

A further turn in his destiny is associated with the following circumstances: near Moscow, it was impossible to organize serial, or mass production of Korolev's military missiles at the required scale. So in 1951, the leadership of the country made a decision to reprofile the Dniepropetrovsk automobile plant in Ukraine. The manager of the established serial design office (SDO), of this plant, Vasiliy Sergeevich Budnik (at the present time, an academician of the National Academy of Sciences of Ukraine), invited leading experts from Korolev's DO (including N. F. Gerasyuta), to organize the serial production of missiles. In 1951, N. F. Gerasyuta relocated to Dniepropetrovsk.

One has to point out that Korolev's craft flew, and fly, utilizing low boiling temperature propellant components (liquid oxygen and kerosene), and this is a major disadvantage for combat missiles: liquid oxygen continuously evaporates, and it is, therefore, difficult to assure continuous combat operational readiness. A group of SDO enthusiasts, among which Nikolai Fedorovich was the only chartered scientist, and "the right hand man" of V. S. Budnik, developed their vehicle

on high-temperature propellant components. Thus, the SDO became a founder of a new trend in the rocket production industry, and, actually, had to wrestle with Korolev, who had unchallengeable authority, as well as a stiff character. Still, the benefits for the military were so great, that the people from Dniepropetrovsk won, and in 1954, based on the serial DO, the Special Design Office No. 586 (Yuzhnoye DO), was set up, which was headed by Mikhail Kuzmich Yangel.

Nikolai Fedorovich made an enormous personal contribution to the maturing and development of Yuzhnoye DO into a powerful scientific and engineering entity, which, at the initial phase of its growth, was staffed with the best representatives of diverse scientific schools of the Soviet Union—graduates from the Moscow Aviation Institute, Moscow Higher Engineering School named after Bauman, Leningrad Military–Mechanical and Instrument Building Institute, Kharkov and Kazan Aviation Institutes, Dniepropetrovsk University, and many others. With his direct involvement, the first missiles of Yuzhnoye DO—SS-4, SS-5, and SS-7—were designed and successfully flight tested, which laid the basis for the founding of the Strategic Rocket Forces of the Soviet Union. The developments of Yuzhnoye DO allowed the assurance of parity between the Soviet Union and the United States in the domain of rocketry and nuclear weapons, thus the eradication of the real threat of a nuclear war, and, as a final point, made it possible for people to live several decades in peace. In 1959, for the development of long-range ballistic missiles (LRBM), of the first generation, N. F. Gerasyuta was awarded the Order of Lenin, in 1961, for outstanding service in the development of rocket and space technology facilities, and of the successful flight of man into outer space, the title of a Hero of Socialist Labor was conferred on him.

N. F. Gerasyuta was not an office scholar. He participated in the flight tests of practically all vehicles developed in Yuzhnoye DO. In 1960 (24 October), in the course of preparatory efforts to launch an intercontinental ballistic missile, a formidable calamity occurred—the missile exploded during liftoff, and nearly 100 people died, including Chief Marshal of Artillery V. M. Nedelin. The catastrophe was benevolent toward N. F. Gerasyuta, and he remained alive.

It was a distinctive characteristic of Nikolai Fedorovich to have a fundamental approach to the solution of problems that arose; he authored a large number of scientific papers and inventions, and was one of the originators of the Dniepropetrovsk scientific rocket production school. But his primary virtue was in the ability to make responsible decisions with respect to very complex technical issues, which led to the required results.

Under the direction of N. F. Gerasyuta, complex engineering and scientific problems related to rocket flight dynamics were solved:

- methods were developed for the maximum utilization of missile energetics capabilities, techniques for fueling missiles with high-temperature propellant components, that take into consideration systems and assemblies checklist characteristics
- a methodology for the dynamic design of combat missiles and spacecraft launch vehicles was implemented
- a methodology for ballistic calculations for rocket launches (computational design of flight tasks, flight routes, and jettisonable components' impact areas) was realized
- methods were elaborated for the solution of flight ballistics of missiles with multiple reentry vehicles and terminal control system (optimal aiming of reentry vehicles at targets, online computation of flight tasks, specific mathematic assurance for planning launches of missiles at top guidance links)
- methods were developed for the solution of reentry vehicles' flight dynamics (including guided facilities), during the trajectory segment of descent through the atmosphere
- problems of dynamics and aerogasdynamics of the missiles' liftoff out of a silo (including a pop-up start), were resolved
- methods were developed to solve the design tasks for the separation of missile stages, and payload separation systems
- problems were solved of the dynamic design of countermeasures against ballistic missile defense systems
- problems of heat exchange and heat shielding of solid propellant rocket motors were solved
- the Computer Engineering Center at Yuzhnoye DO, was established, et cetera.

The missiles developed by Yuzhnoye DO feature a lot of ingenious engineering and technological solutions, which N. F. Gerasyuta endowed through his immense personal contribution. One may address some of them.

Orbital Warhead Module

During the 1960s, the United States commenced to deploy the Safeguard Ballistic Missile Defense (BMD) system. Naturally, it reckoned on obtaining a lead in the arms race versus the Soviet Union. One had to find an adequate rejoinder. That became the development of the SS-9 missile with an orbital warhead module. The idea was that the missile could be launched from the territory

of the Soviet Union, but not toward the United States (as is a common ballistic missile), but, for instance, in the opposite direction. In this particular case, the warhead module is delivered into orbit, and could then descend at any point on U.S. territory, and practically from any direction. Under the supervision of N. F. Gerasyuta, a complex set of vehicle ballistics and guidance problems was solved, which permitted, at the limited energy capabilities of the SS-9 missile, the assurance of the insertion of the warhead module into orbit, within the entire range of launch azimuths for the missile. Creation of the SS-9 missile with the orbital module meant that the entire BMD system of the United States and Canada turned out to be inefficient for the protection of their territory from the southern direction. As a result, the United States was impelled to commence negotiations on disarmament and the prohibition of ballistic missile defense. In return, the Soviet Union made the commitment to destroy the SS-9 missile, and its orbital warhead module.

Multiple Reentry Vehicles

In the Soviet Union, Nikolai Fedorovich coauthored the invention of the first multiple reentry vehicle (MRV), equipped with several independently targetable warheads. This allowed a dramatic augmentation of the effectiveness of battle applications of a missile system. For example, as regards the SS-18–10, its combat ordnance covers a target area of 800 by 400 km. While introducing the MRVs, a package of complicated problems was solved, associated with the optimization of reentry vehicles aimed at diverse targets, development of guidance algorithms and onboard flight computer software, mathematical confirmation of launch planning tasks within top controllability links ("ballistic filter"), et cetera.

Ballistic Missile Defense Penetration Facilities Complex (BMD PFC)

One of the most important and intricate tasks in the combat application of missile systems is the penetration of the ballistic missile defense measures of a likely enemy. Under the direction of N. F. Gerasyuta, a series of intricate problems was solved, on the implementation of ballistic missile defense penetration capabilities: development of general design principles for BMD PFCs, methods for their ground and flight development upgrade, design of a likely enemy's BMD models, optimization of BMD PFC configuration, development of methods for the assessment of BMD PFC efficiency, development of a radiolocation image of decoys, development of algorithms for the arrangement of offensive battle arrays, and so forth.

During the deployment of the multiple reentry vehicle payload, each combat component flies with tens of decoys, which are virtually impossible to discriminate from a combat reentry vehicle. This makes the interception of combat components by the BMD measures unlikely, and, thereby, a BMD system can be penetrated. In recognition of the development of the SS-7 missile with the BMD penetration facilities complex, N. F. Gerasyuta together with M. K. Yangel received State Prizes.

Maneuvering Reentry Vehicle

For strategic ballistic missiles of the last generation, a maneuvering reentry vehicle was developed, performing a special maneuver within a descending atmospheric trajectory segment, for penetration of a ballistic missile defense system. Under the direction of N. F. Gerasyuta, a number of complex problems were solved, in flight dynamics, and in the construction of the reentry vehicle's controllability system, which is subject to the ablation of the insulation coating, and variation of its aerodynamics.

Missile Pop-Up Liftoff

The military doctrine of the Soviet Union foresaw launches of intercontinental ballistic missiles only as a reactive remedy to a nuclear strike of a potential enemy. Such a formulation of the task significantly complicated the solution of many issues. In particular, missiles were to be emplaced into highly protected silos, to provide protection against a nuclear impact on the missile's structure, and other arrangements. At Yuzhnoye DO, there was put forward an idea of a pop-up liftoff, in which a missile is popped out of a canister, and then, its own propulsion system is activated. For heavy missiles with a weight of approximately 200 tons—this is an exceptionally difficult, integrated problem, which not even the leadership of the Ministry of Defense believed could be solved. Nevertheless, this problem was solved.

"Requital" Missile

A ballistic missile flies from the United States to the Soviet Union in about 40–50 minutes, which provides a capability to make a decision, in regard to a retaliatory strike. When NATO deployed its missiles in Europe, and the flight time of missiles decreased to 8–19 minutes, no time would be left for making a decision. In order to lower the temptation to deliver the first nuclear strike to the Soviet Union, there was contrived a conception of "a requital missile." When everything lies in ruins and communication is disrupted, this missile starts from a

super-protected launcher and sends a signal for the retaliatory strike to all surviving missiles. The Americans designated the control system for this automatic, second strike launch capability, the "Dead Hand."

Conclusion

N. F. Gerasyuta contributed greatly to the formation of the Ukrainian scientific school of ballistics and dynamics experts. He attached paramount importance to engineering and scientific manpower development. Nikolai Fedorovich is one of the originators of the Applied Physics Department of Dniepropetrovsk University, which, during 50 years of its existence, graduated more than 20,000 specialists for the rocketry–space industry. As a Department Head and Professor at Dniepropetrovsk University, he authored a fundamental course of lectures on dynamics and LRBM controllability, continuously supervised students' diploma design efforts, and the scientific work of advanced students. He assured the preparation of four doctorate degree holders and about 60 candidates of science degrees. In coauthorship with Professor A. A. Lebedev, from the Moscow Aviation Institute, he wrote the *Rocket Ballistics* monograph, which became a handbook not only for students and advanced students, but also for young engineers and scientists of the rocketry and space industries.

To Nikolai Fedorovich, the conception a "scholar–science organizer" is applicable in full. He was a sponsor in establishing the sector of engineering mechanics problems in Dniepropetrovsk, which later became the Institute of Engineering Mechanics of the National Academy of Sciences of Ukraine. N. F. Gerasyuta is one of the founders of the Dniepropetrovsk rocket production scientific school. In 1967, he became a corresponding member of the Academy of Sciences of Ukraine.

A prominent scientist, talented designer, noteworthy individual, and wise principal, N. F. Gerasyuta possessed great authority among such outstanding scientists and pioneers of rocketry–space technology as academicians M. V. Keldysh, V. P. Glushko, M. K. Yangel, B. E. Paton, B. N. Petrov, N. A. Pilyugin, V. I. Kuznetsov, V. F. Utkin, V. S. Budnik, Yu. A. Mozjorin, and many others.