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Chapter 12

The Role of Academician Sergei P. Korolev in the Development of Space Rocket Vehicles for Lunar Exploration with the Help of Manned Spaceships*

V. P. Mishin†

Introduction

Until now, the role of Academician Sergei P. Korolev in the development of space rocket systems for lunar exploration with the help of manned spaceships has been passed over in silence. But now, when the curtain of secrecy on the subject is removed, the time to recount this aspect of S. P. Korolev's activities has come.

He was the first one in this country who looked for, and laid down, actual ways for a circumlunar fly-by and for landing a cosmonaut on the Moon's surface, with his subsequent return to the Earth. Lunar explorations with the help of automatic spacecraft, or the so-called "Luna" automatic interplanetary stations, were stages of the developmental work on components and instruments of space rocket systems for lunar exploration by means of manned spaceships. The above

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† Moscow Aviation Institute.

explorations were the prelude to Moon exploration directly by a spaceman. I would like to recount this role of S. P. Korolev in the present report.

How it Started

S. P. Korolev and his comrades-in-arms realized that there was a need to increase a payload injected into near-Earth orbits, in order to improve space operations with the help of manned spaceships. This aim could be achieved with the help of either superheavy or medium space boosters. In the latter case, an Earth-orbital docking was required. At the end of 1961, S. P. Korolev's experimental design bureau were given the task to develop the N1 space booster that could inject a payload of 40-50 tons into a near-Earth orbit (developing time—1962-1965), and the N1 rocket with a payload of 60-80 tons (developing time—1963-1970). Later, the terms fixed for the development of those space boosters were adjusted repeatedly (for different reasons). Also in 1961, V. N. Chelomey's firm was charged with the job of developing a space rocket complex designated for a circumlunar fly-by. The task of landing an expedition on the Moon's surface was not set at all at that moment. Therefore, S. P. Korolev was somehow discharged from the lunar program. In 1962, the plan was revised once again. The goal was set—to concentrate potentialities and resources to create a complex for a manned circumlunar fly-by on the basis of the UR500 space booster developed by Chelomey's experimental design bureau. The activities on the N1 space booster were restricted to the development of a preliminary design only.

In July of 1962, the expert commission headed by M. V. Keldysh considered the project developed in such an uncertain situation, and it concluded that the creation of a space booster with a payload mass of 75 tons and the complex total launching mass of 2,200 tons was necessary (and possible). Flight and design tests were supposed to begin in 1965, on condition that a launching site would be constructed and put into operation by that time.

The Academy of Sciences had to determine objectives and to put forward a proposal to develop space objects to be sent into space by this space booster, also within the same resolution. Exactly in this period of developing a preliminary design, the discord between S. P. Korolev and V. P. Glushko took place. Korolev and his followers stood up for the necessity of the use of high energy and non-toxic propellant components (liquid oxygen, liquid hydrogen and hydrocarbon fuel) in rocket engines. V. P. Glushko persisted in such high-boiling and toxic components as nitrogen tetroxide and unsymmetric dimethylhydrazine, with liquid hydrogen and liquid fluorine as cryogenic components. V. P. Glushko rejected the idea of developing lox/liquid hydrogen and lox/kerosene engines for the N1 space booster. Korolev had to address the general designer of aero-engines, N. D. Kouznetsov, who undertook the development of such liquid-propellant engines, though this kind of activity was different from his previous work. N. D. Kouznetsov had to set up a bench-test base and to master new technologies in his experimental design bureau and at the plant where the engines were manufactured.

Only in the middle of 1964 (Saturn-Apollo project activities had been pursued on a broad footing already) was it decided that the landing of an expedition on the Moon's surface should be the most important task.

The study of various versions of such expeditions was performed in Korolev's experimental design bureau. Originally he showed preference for multi-launch complexes assembled from parts in a near-Earth orbit. Such a scheme for a lunar expedition had something in common, to a degree, with the activities on the Soyuz project, which was being developed in the experimental design bureau. The project envisaged a docking of two manned spaceships on a near-Earth orbit, and the transition of cosmonauts from one spaceship to another through open space. The U.S.A., as was mentioned before, had chosen a single-launch scheme.

The American project urged the Soviet leadership to set the task of developing projects for space boosters, allowing the lunar expedition in one launch. Such tasks were given, along with Korolev's firm, to experimental design bureaus headed by K. M. Yangel and V. N. Chelomey. Their designs (R56 and UR700 space boosters respectively) were mainly based on Glushko's engines.

By the end of 1964, a pre-preliminary design of an N1-L3 lunar rocket complex was developed in Korolev's experimental design bureau. It envisaged the landing of one spaceman on the Moon, while the other one would be in a lunar orbital spaceship on a near-Moon orbit, and their return to Earth in a descent vehicle which was part of the lunar orbital spaceship. The expedition was to be provided by one launch of the N1 space booster. It was planned to increase the payload mass from 75 to 92 tons, later to 95 tons (and more), for this purpose. The options that could provide the injection of such payload, avoiding a radical remaking of the issued technical documentation, structure of rocket pods and specialized technological equipment, were considered. It was planned:

- To increase the launch mass from 2,200 to 2,700 tons.
- To mount six additional liquid-propellant engines in the central part of the first stage (in the "A" pod).

- To boost liquid-propellant engines of power plants of rocket pods for the first three stages ("A," "B," "C" pods) an average of 2 percent by means of the introduction of a "flexible" program of engine thrust control.
- To use, in the future, liquid-propellant engines of higher specific thrust, at the expense of the utilization of liquid oxygen and hydrogen as a fuel, for rocket pods of upper stages.

The N1 space booster had an original general-arrangement and force-and-structural arrangement diagram. Propellant compartments of the "A," "B," "C" rocket pods contained external ball tanks. For the first time in the U.S.S.R. (and perhaps in the world) pre-pumps were used in turbopump units of liquid-propellant engines.

Components of the tanks' structure and compartments were transported from manufacturing factories to the Cosmodrome by ordinary railway facilities. Americans delivered rocket pods assembled at manufacturing factories with the help of special barges on a specially built canal that, naturally, required large additional expenses.

The "A," "B," and "C" rocket pods were multi-engine ones. Thus, the "A" rocket pod consisted of twenty-four peripheral and six central liquid-propellant engines with the by-Earth nominal thrust of 154 tf. Eight liquid-propellant engines with high-altitude nozzles and a vacuum nominal thrust of 179 tf were mounted on the "B" rocket pod, while four engines with the vacuum nominal thrust of 41 tf were mounted on the "C" pod. These engines had the same principal pneumatic system as the "A" pod engines.

The dimensions of the "A" pod single liquid-propellant engine were determined in such a way as to provide minimum cost for their development and production. The reserving of single liquid-propellant engines was envisaged to increase reliability. Thus, the first stage could promote the flight with two pairs of opposite peripheral cut-off engines, the second stage with one pair, and the third with one cut-off engine.

The control of the first and second stages of the space booster, relative to lateral axes (through the pitch and yaw channels), was implemented by the thrust mismatching of opposite peripheral hard-mounted engines, and the control relative to longitudinal axis (the rotation channel) was effected by oscillating nozzles placed along the periphery of rocket pods, through which gas taken after the turbopump unit turbines of single peripheral engines effluxed. The control of the third stage was implemented by gimbaling its single engines. All single liquid-propellant engines had systems for supplying propellant components to the combustion chamber with the help of the turbopump unit, with afterburning of a propulsive mass after it exited the turbine. They used liquid oxygen and hydrogen and had high energy-mass characteristics for that time.

Unlike Saturn-Apollo, the N1-L3 components were assembled and tested in the assembly-and-test building (on a special erector) in a horizontal position. The assembly of the lunar rocket complex—the leading unit—was performed in another building, called the assembly-and-test building for space objects. The lunar rocket complex consisted of "D" and "E" rocket pods, the lunar orbital spaceship with its rocket pod, lunar spaceship, escape system and nose fairing. The assembled N1-L3 was transported from the assembly-and-test building by two twin diesel locomotives on two railway lines to the launching structure, where it was erected into a vertical position.

Comparing the scheme of the lunar expedition of the Saturn-Apollo project with the Soviet scheme, one should admit the American one had better characteristics. According to the American scheme, three astronauts were to be delivered to lunar orbit, while the Soviet scheme envisaged two spacemen; two astronauts were to land, in the American plan, on the Moon's surface, but only one according to the Soviet scheme. Owing to the use of liquid hydrogen in the second and third Saturn stages, and a more favorable location of the U.S. space port at Cape Canaveral (from the viewpoint of the Earth's rotation when launching spaceships eastwards) compared with the location of the Baikonur Cosmodrome, the Saturn space booster injected 10 percent more payload with the same launching mass to the near-Earth orbit. Also, Saturn-Apollo had one rocket pod less than N1-L3; therefore, it was simpler and had a higher reliability in principle. And finally, the Americans had introduced methods for increasing the operating reliability of power plants of rocket pods that envisaged the performance of their pre-flight bench firing tests and their final assembly without an overhaul. The implementation of those methods required large funds for the construction of special firing bench-tests. And required resources were allotted.

S. P. Korolev and his comrades-in-arms were quite aware of the situation. But the current situation laid certain restrictions on terms, allotted funds and production capacities; therefore, the American method was not adopted. The aspiration to outstrip the U.S.A. in landing the expedition on the Moon with minimum costs was the main factor in Soviet decision making.

Unfortunately, as was mentioned before, two independent programs were developed in the U.S.S.R., unlike the U.S.A. One of the programs related to the manned circumlunar fly-by; the second one involved landing the expedition on the Moon's surface. Three space booster designs (N1, R56, UR00) had been developed within the second program. In the U.S.A., all the efforts were directed toward the implementation of the Saturn-Apollo integral program which got nation-wide support. The circumlunar fly-by by astronauts, with their subsequent return to Earth, was regarded as a stage of the expedition for landing men on the Moon.

S. P. Korolev made repeated attempts to combine both Soviet projects or, at least, to make the maximum use of the achievements of one of the programs for the other one. The first trial was made in 1961, when he suggested using N1 (the first version but with the payload mass of 75 tons) to fly around the Moon with two cosmonauts and their landing on Earth in a descent vehicle with second cosmic speed.

He made his second attempt in 1964, when he suggested using a rocket consisting of upper rocket pods "B," "C," and "D," and a lunar spaceship from the N1-L3 system, for the same purpose. But all of his efforts failed.

In the second half of 1965, it became clear that the experimental design bureau, headed by V. N. Chelomey, would not be able to provide the priority of the U.S.S.R. in the implementation of the manned circumlunar fly-by, because of a lag in its activities to develop a lunar fly-by system. Korolev suggested using the "E" rocket pod and a lunar orbital spaceship of the N1-L3 complex for this purpose. The suggestion was adopted after long and hot discussions.

Thus, the UR500K-L1 program that envisaged the circumlunar fly-by by two cosmonauts, with their return to the Earth in a descent vehicle with second cosmic speed, was born at the end of 1965. The launch from Earth was to be performed by the UR500K (Proton) space booster with the "E" rocket pod. The manned spaceship (it was called 7K-L1), as was mentioned before, was developed on the basis of a lunar orbital spaceship of the N1-L3 project. S. P. Korolev was appointed the executive for the implementation of the UR500K-L1 program.

It is necessary to mark his essential role in setting up on-ground services whose importance in controlling manned spaceships is very substantial. Such services began to be set up in the period of launching automated space vehicles. S. P. Korolev saw the prospects of using computers in the control system of a spaceship movement. His experimental design bureau was one of the first to apply computers, first for ballistic, structural, aerodynamic and other designs, and then in the control system of a spaceship movement in real time.

The network of instrumentation control centers was established within a short period of time; they receive telemetry and trajectory information and transmit it through reliable channels of jam-proof communication to the coordination computing center, which processes it and then transmits it to the mission control center in a form acceptable for making decisions. The mission control center makes decisions on the basis of these findings and sends commands to space vehicles and ships. There is a two-way communication between manned spaceships and the mission control center.

It follows from the above that, already in the beginning of the 1960s, S. P. Korolev had to deal with sophisticated technical systems which were developed and operated by numerous groups of specialists with a variety of professional orientations.

Conclusion

Manned flights to the Moon and back to Earth were the dream of S. P. Korolev. This article illustrates that all of his activities were connected with the implementation of such flights. The work to create a space rocket complex with the Molniya (Lightning) 4-stage space booster and the second generation Luna automated space vehicle for a soft landing on the Moon's surface was a necessary stage in the implementation of such flights.

Soyuz project activities started during his life-time and envisaged the docking of 2 manned spaceships in near-Earth orbit, and the transition of cosmonauts from one spaceship to the other one through open space, although some elements of the project, of course, were developed subsequently. A Soviet-American Soyuz-Apollo program, concluding with the near-Earth orbital docking of Soyuz and Apollo spaceships launched from spaceports located on different continents, was successfully implemented on the basis of the above activities. DOS-Salyut long-term orbital stations and manned spaceships for the delivery and return of cosmonauts to these stations, as well as automatic transport vehicles for cargo deliveries to the stations, were developed on the same basis.

Salyut long-term orbital stations laid the basis for the development of the Mir long-term orbital stations of a new generation with 6 docking joints. UR500K-L1 project activities, envisaging the circumlunar fly-by of two cosmonauts with their landing on Earth in a descent vehicle with second cosmic speed, began in the lifetime of S. P. Korolev, with his active participation.

His followers made everything possible for the successful completion of those activities—unfortunately, with some delay in comparison to the American program—and it was not their fault that such manned flights never took place. The Proton 4-stage space booster, with "E" and "EM" rocket pods developed for that purpose, is the basic space booster which injects automatic space vehicles of a new generation into interplanetary trajectories. The above space boosters were also used to launch the Vega and Phobos automatic space vehicles.

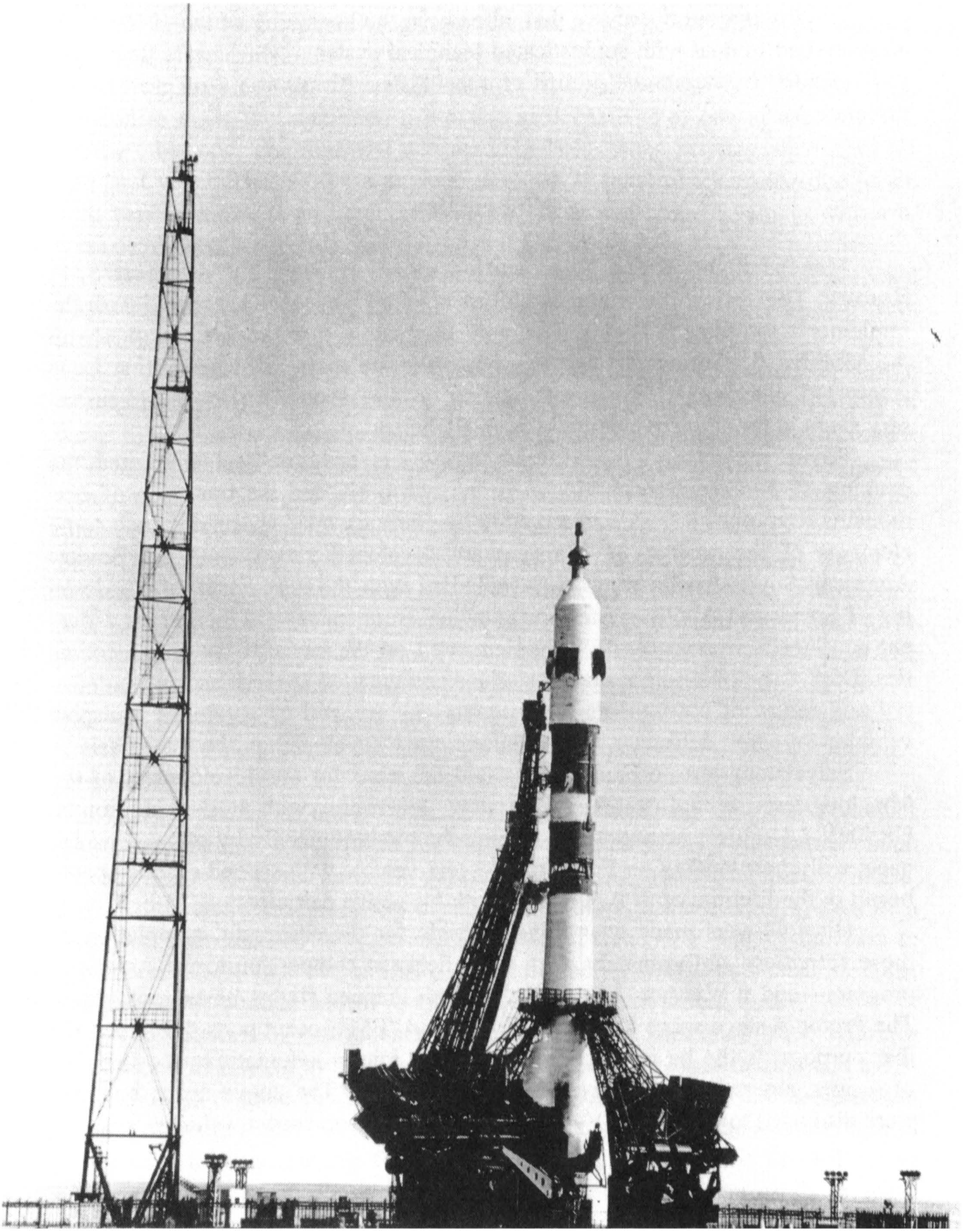

Figure 1 Soyuz with launch vehicle.

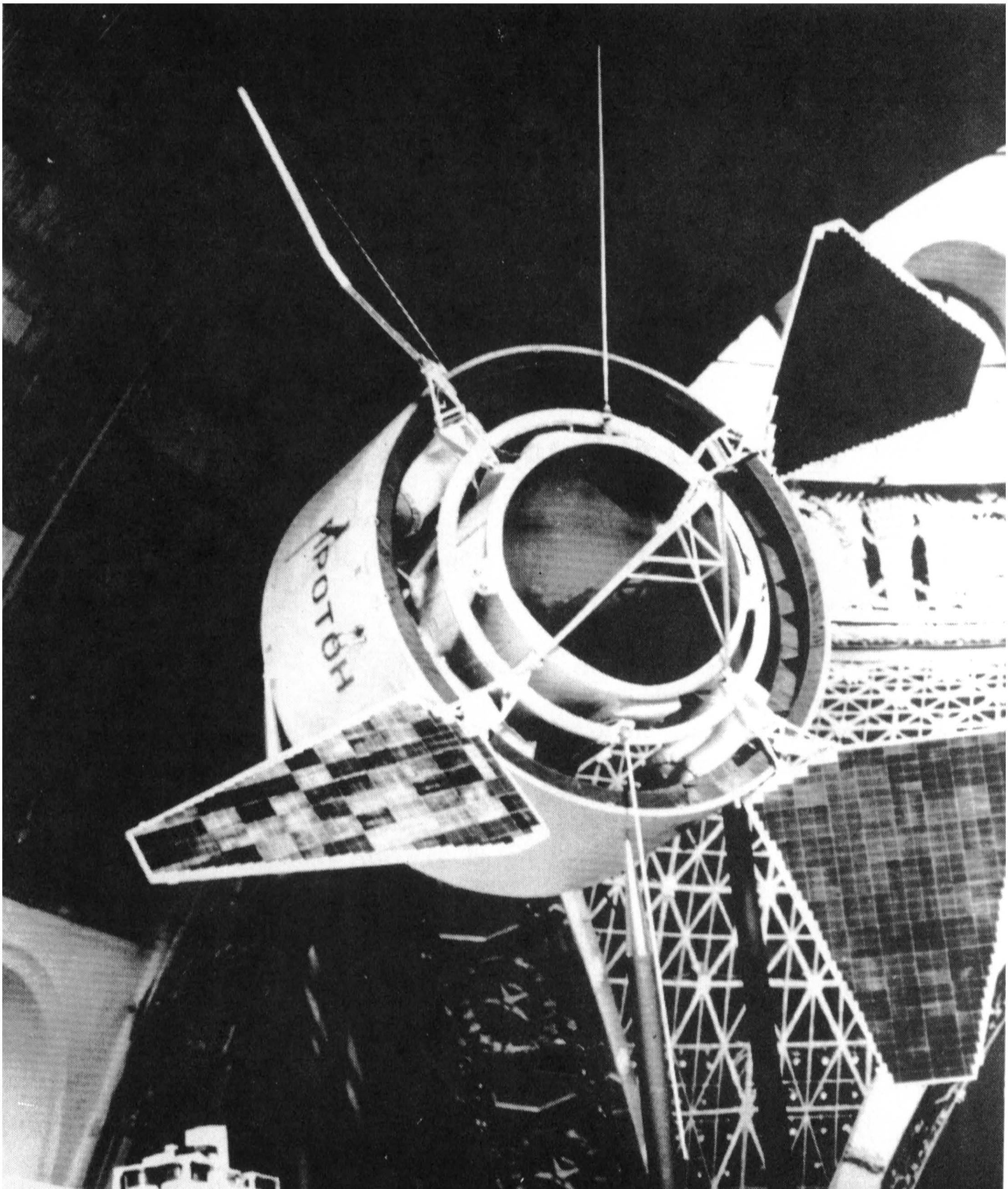

Figure 2 Proton-1.