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Chapter 34

The Soviet Program of Moon Surface Research (1966-1979)*

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This year we celebrate the 25^{th} anniversary of the first landing of astronauts on the Moon under the "Apollo" program. When we mention the parallel development of a Soviet program of Moon research we usually mean the program of piloted flights, which was not implemented due to late and insufficient financing. People often forget that another program of Moon research with the help of automatic space vehicles which included lunar soil delivery was very successfully developed.

Studying the Moon began in 1959 by photographing its back side. "Luna-9" (1966) was the first automatic space vehicle which landed on the Moon and transmitted photos of its surface made from a very short distance. This was the last work done by S. P. Korolev. These photos made it possible to observe the micro-relief of the lunar soil, its stones and hollows. This was a way to disprove the hypothesis about the dust structure of its surface. This laid solid ground for the development of the further Moon vehicles to land on its surface. These data were completed by information on the mechanical characteristics of the lunar soil in the end of the same year ("Luna 13"). Some parallel research was conducted by American scientists with the help of "Surveyor" space vehicles.

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In 1969 a more powerful launch vehicle was introduced. It allowed an increase in the mass of the Moon automatic space vehicles (from 1.5 to more than 5.5 tons) and, after that, the start of a unique program of lunar surface study, which was not developed in the USA space program (here, of course, we mean automatic space vehicles). There were two main directions in the new program of lunar surface study: delivering the samples of the lunar soil and creating a moving long-working laboratory to study large areas of the lunar surface.

To solve both tasks a unified Moon descent module was designed. The flight to the Moon and landing were carried out along the usual scheme with its necessary element—the space vehicle orbit correction, using rather complicated optical and gyroscopic devices.

At first it seemed that if we set a task of delivering the lunar soil to a given place on the Earth then it would be necessary to correct the return trajectory. This, in turn, would require the use of complicated optical and gyroscopic devices, as well as correcting the rocket engine, a rather complicated command radio line, etc. All this made it practically impossible to deliver lunar soil back to the Earth, if we consider the permissible mass of the returning vehicle (vehicles "Moon-Earth"), which could be delivered to the Moon. An unexpected solution was found by specialists in the mechanics of space flight at the Moscow Institute of Applied Mathematics headed by D. E. Okhotsimsky.

The mathematic analysis showed that among various possible trajectories for the return flight from the Moon to the Earth there existed a small class of passive flight trajectories, which could be provided by a simple vertical start from the Moon. These trajectories can be called "passive" as they do not presuppose any active influence on the returning space vehicle (no correction of its trajectory). They exist only on the route Moon-Earth (but not backwards) since the Earth is a powerful attracting center. When analyzing passive trajectories it was found out that the landing point of the Earth depends on the starting point of the Moon. It was also discovered that due to the fact that the landing of the Moon module on the Moon had to be performed with the maximum possible exactness, about ±10 km. Such an exact landing from the intermediate orbit of the artificial Moon satellite required profound knowledge of the lunar gravitation field. To specify our knowledge on the gravitation field the space vehicles "Luna-10, -11, -12 and -14" were launched into different satellite orbits around the Moon. All the necessary data about the lunar gravitation field were received by long observations of the vehicles. Relevant constructive decisions were also necessary to conduct the return of the Moon space vehicle to the Earth: the landing and returning Moon modules had to provide the exact vertical start of the returning module, the exact starting time and also to provide the returning module with the exact necessary speed.

This was enough to ensure the return of the module with samples of lunar soil to the Earth, but the predicted landing place on the Earth was too wide to arrange an effective search for the comparatively small returning vehicle. It required specifications on the factual returning trajectory based on trajectorial measurements. But the mass of the required radio-technical equipment was too large, so ordinary methods could not be applied.

The way out was found by elaborating a special set of especially light equipment. The mass was reduced by means of transition from the decimeter to the meter band. It allowed the reduction of the required mass of the equipment greatly, but, at the same time, led to exactness of trajectory measurements. That was why, in addition to the radio equipment of the meter band, astronomic observatories joined this operation by measuring angular coordinates of the returning space vehicle starting from a distance of 150,000 km from the Earth. A successful delivery of lunar soil samples proved that the decisions were right.

This program began in September 1970 with the flight of the space vehicle "Luna-16," which landed on the Moon in the region of Mare Fecinditatis. A special device of the manipulator type could drill soil of any solidity. The point of drilling was controlled from the Earth. The sample of soil was placed into a container, then delivered to the Earth. In the first experiment the depth was comparatively small, less than ½ m, so we can say that the soil was taken from the surface of the Moon.

The next flight, under the same program, was carried out by the space vehicle "Luna-20" in February 1972. Unlike the first flight the landing was made in the mountain region between Mare Fecunditatis and Mare Crisium, which made it possible to compare samples of soil of "mare" and "continental" regions.

The flight of the space vehicle "Luna 23" in October 1974 was unsuccessful in the respect that a landing was made in a region with bad relief, and as a result the soil-collecting device was damaged.

But the last flight under the program ("Luna-24"), which took place in August 1976, was especially interesting. The vehicle landed in the southern part of Mare Crisium, but the main peculiarity of the flight was not the place of landing but the fact that the soil collecting device could drill up to 2 m deep. The sample then returned to the Earth in a container without changing the lunar rock stratigraphy. This was achieved the following way: the rock was put into a flexible pipe which was, in turn, put into a comparatively small returning module of a spherical shape.

Another research program included the landing of moving research stations. The two aims of this program were: to broaden the research area (not limiting it to the place of landing only) and at the same time to test the construction of "lunokhod," a kind of a special Moon automobile. Lunokhod had a specific remote control device, so the "team" on the Earth controlled the lunokhod by radio. Here scientists had to work out the method of control on an unknown relief using TV. It was rather difficult since the system had to function with a rather big delay—the time between the command and observation of its fulfillment was equal to the time necessary for radio waves to reach the Moon and then come back with the "answer" from "Lunokhod." According to calculations this time was about three seconds. This delay made the control process rather difficult. Apart from the visual data of the "Lunokhod" moving along the lunar surface the data received through telemetry about the condition of the Lunokhod's systems were constantly reviewed. In cases when a list of dangerous proportions was reached, the machine stopped its movement automatically.

The construction of "Lunokhod" provided for its work not only during the moonlit "day" but also during the moonlit "night" when the drop in temperature should have put it out of action. The necessary temperature regime was provided by an isotopic source of heat, which warmed gas circulating in the thermoregulating system. Solar batteries, as usual, were the source of electric power.

The first "Lunokhod" was delivered to the surface of the Moon by the space vehicle "Luna-17" in September 1971. It had an active life of about one year, covered more than 10 rm, transmitted more that 200 panoramas of the Moon, made more than 20,000 photos; the physio-mechanical characteristics of the soil were studied from more than 500 points on its route, and at 25 points a chemical analysis was made as well.

The second modified "Lunokhod" with upgraded equipment was delivered to the surface of the Moon by the space vehicle "Luna-21" in January 1973. It carried out an analogous set of research. During its operational life (about ½ year) it covered 37 km along a difficult zone where mare and continent meet.

In general "Lunokhods" helped to conduct large volume of research work —studying the topographic geomorphological characteristics of the area, defining chemical compounds and physio-mechanical characteristics of the lunar soil, as well as studying the radiation situation of circumlunar space and the lunar surface. More than that, space radiation was studied, magnetic measurements were made and laser locating of the Moon was conducted.

If taken as a whole the soviet Moon program from "Luna-9" to "Luna-24" headed by G. N. Babakin was comprehensive and detailed. The lunar gravitation field, characteristics of its surface, especially soil, which was taken not only at particular points but on rather long routes (thus excluding the element of chance and providing average characteristics of its soil with possible variations), were studied under the program. The samples of lunar soil delivered by space vehicles of the route the Earth – the Moon – the Earth were then studied more thoroughly in the Earth laboratories.

After the successful implementation of this scientific program we can ask the question: Were the piloted flights to the Moon necessary if all the scientific data and materials could be delivered by automatic space vehicles? Could not the money spent on the "Apollo" program have been spent more effectively by creating an analogous USA program of Moon research by automates? Judging by the process of receiving scientific materials it would be rather rational—automates nowadays are able to do nearly everything a man is able to do and a lot more that a man cannot. But the motivation of a man's actions cannot be limited to studying nature and its laws. If this were true human behavior would seem irrational.

Why do mountaineers risk their lives climbing mountains? Yearning to see and experience by oneself the unknown together with a sporting aspiration to overcome difficulties were not for once the main reason for many heroic exploits which became the history of mankind. If we judge the "Apollo" program from this angle then it becomes understandable, rational and necessary.