as
ZDR
on

National Aeronautics and Space Administration
Goddard Space Flight Center
Contract No. NAS-5-12487

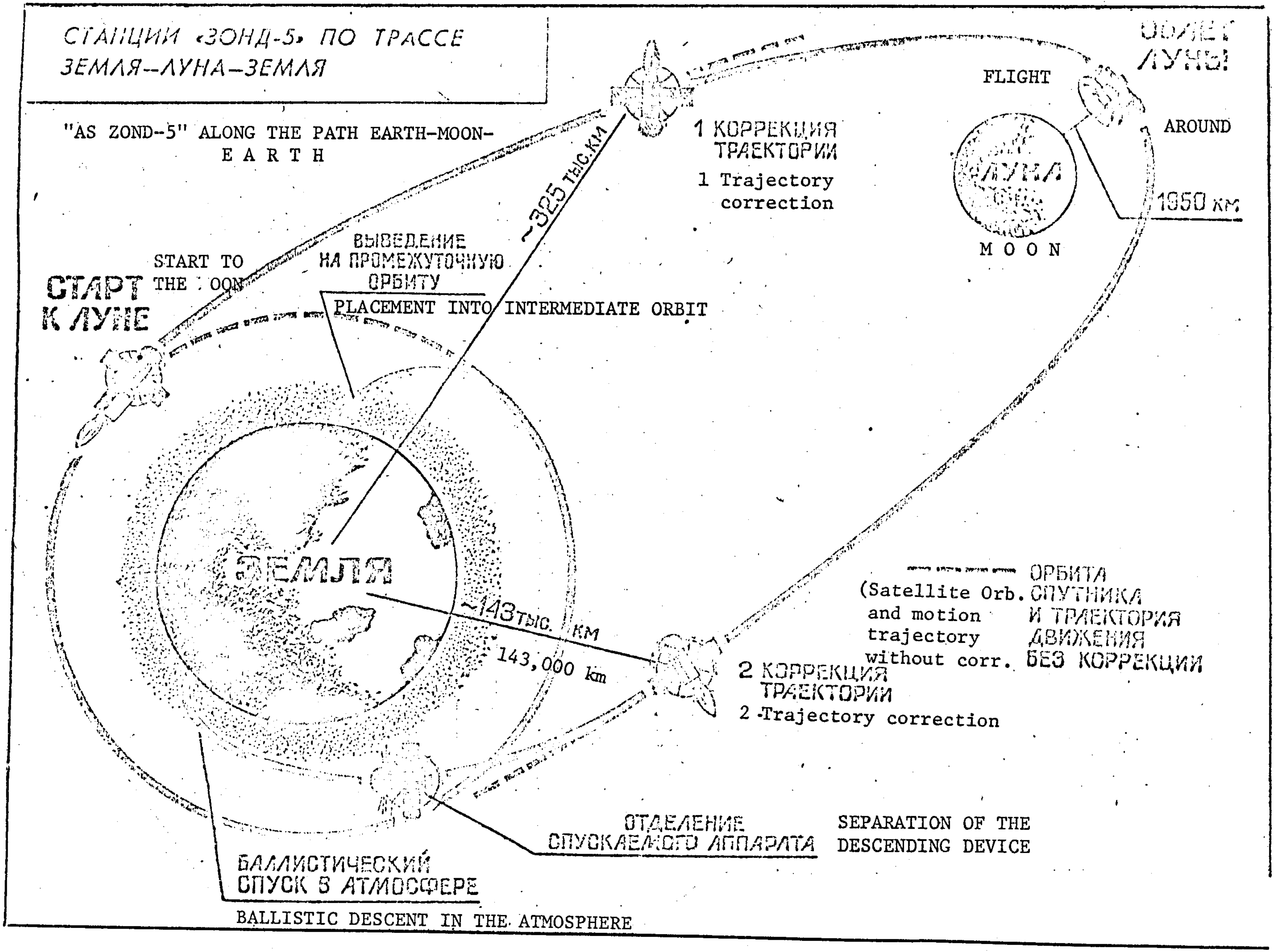
NT

ST — PR — LPS — 10759

THE AUTOMATIC STATION "ZOND-5" FLEW AROUND THE MOON AND RETURNED TO EARTH

by
Prof. A. DMITRIYEV
(USSR)

30 SEPTEMBER 1968



СТАНЦИИ «ЗОНД-5» ПО ТРАССЕ
ЗЕМЛЯ–ЛУНА–ЗЕМЛЯ
"AS ZOND-5" ALONG THE PATH EARTH-MOON-EARTH
СТАРТ К ЛУНЕ
START TO THE MOON
ВЫВЕДЕНИЕ НА ПРОМЕЖУТОЧНУЮ ОРБИТУ
PLACEMENT INTO INTERMEDIATE ORBIT
~325 тыс.км
1 КОРРЕКЦИЯ ТРАЕКТОРИИ
1 Trajectory correction
FLIGHT
AROUND
ЛУНА
MOON
1950 км
ЗЕМЛЯ
~143 тыс. км
143,000 km
ОРБИТА СПУТНИКА И ТРАЕКТОРИЯ ДВИЖЕНИЯ БЕЗ КОРРЕКЦИИ
(Satellite Orb. and motion trajectory without corr.
2 КОРРЕКЦИЯ ТРАЕКТОРИИ
2 Trajectory correction
ОТДЕЛЕНИЕ СПУСКАЕМОГО АППАРАТА
SEPARATION OF THE DESCENDING DEVICE
БАЛЛИСТИЧЕСКИЙ СПУСК В АТМОСФЕРЕ
BALLISTIC DESCENT IN THE ATMOSPHERE

THE AUTOMATIC STATION "ZOND-5" FLEW AROUND THE MOON AND RETURNED TO EARTH

Newspaper "PRAVDA", No.269
Moscow, 25 September 1968

Column by Professor
A. DMITRIYEV

SUMMARY

This is the first article of its kind, describing the launching of ZOND-5, its apparatus, the various maneuvers over the trajectory to, past the Moon and return to Earth. Apparatus is briefly described and the conditions for accurate hitting of the soft landing spot are amply discussed.

*
* *

Various types of automatic crafts launched in the Soviet Union, conduct a variety of scientific investigations in the near-Earth and far outer space, near celestial bodies and on their surface; they also broadly experiment the conditions in space flight of new onboard systems and devices

Satellites of the "Kosmos" series conduct broad investigations of upper atmosphere layers and of the near-Earth outer space in accord with the program publicized by TASS since 16 March 1962.

The investigation of the interplanetary space, of Moon and planets is performed by automatic stations of the "ZOND", "LUNA", "MARS" and "VENERA" types. So, as early as in 1959, the Soviet automatic station "LUNA-3" flew for the first time past the Moon, photographing its far side and transmitting the pictures to Earth. Another Soviet AS "ZOND-3" took photographs of the part of the Moon, missed by "LUNA-3". The photographs of Moon's surface obtained by "ZOND-3" were transmitted to Earth from distances exceeding 30 million kilometers.

The obtaining of these photographs allowed the Soviet scientists to disclose the secrets of the far side of the Moon and to resolve some of the problems linked with the nature of the part of the Moon, invisible from Earth.

Outstanding results in Moon investigations, alongside with that of near-lunar space, were obtained in subsequent years.

On 3 February 1966 soft landing was accomplished by "LUNA-9" for the first time in the world, while on 3 April of the same year "LUNA-10", the first AMS, was placed into the lunar orbit.

Following "LUNA-10", AS "LUNA-11, -12 and -14 were successively placed in the lunar orbit, while "LUNA-13" effected again a soft landing on the Moon's surface.

Both "LUNA-9" and "LUNA-13" transmitted to Earth television pictures of lunar panorama with valuable information concerning its ground, while the near-lunar space was studied with the aid of lunar satellites; here too the surface was photographed and the gravitational field of the Moon was studied.

A large volume of scientific information on physical processes taking place in interplanetary space was transmitted by Soviet automatic stations "VENERA-1", "MARS-'", "VENERA-2" and "VENERA-3".

On 18 October 1967, Soviet science wrote in still another glorious page concerning the mastering of outer space: the automatic station "VENERA-4" effected a smooth descent through the atmosphere of Venus and a smooth landing on its surface. It transmitted to Earth for the first time in the world a unique scientific information on the phsyical properties of this mysterious planet.

However, none of the enumerated spacecrafts was ever returned to Earth, inasmuch as over these stages of development of space technology, such a problem could not be posed to them. The information obtained was telemeter d to Earth. But, however perfect radiotelemetry and television means may be, the transmission of information was still to a certain extent limited.

Moreover, not all the information obtained by scientific devices can be analyzed on board of the spacecraft. Thus, for example, the results of action of high energy rays on the investigated matter and the scientific devices may be subject to deeper and more effective study by scientists on the ground only, upon return of the station from its journey in outer space.

The development of space technology raises before scientists still more complex problems in the investigations of the interplanetary space and of the solar system's planets.

Such problems as the study of planet surfaces' crust and of the composition of chemical elements and minerals forming it, the search of traces of living organisms have now already become realistic.

Of great scientific interest is also the obtaining of direct photographs of surfaces and emission spectra of celestial bodies, free from interferences and distortions by telemetry.

This is why the subsequent development of astronautics has for terms of reference the question of delivery of information from outer space directly in scientist's laboratory. Such a problem concerning the processing of means and of methods of spacecraft return from interplanetary paths was raised before the Soviet station "ZOND-5", and it was successfully fulfilled.

*

* *

APPARATUS OF THE AS "ZOND-5" AND THE FUNDAMENTAL SCIENTIFIC AND TECHNICAL INVESTIGATIONS

AS "ZOND-5" was constructed in two parts: the descending device with scientific apparatus, and a device compartment with systems assuring the successful flight of the station.

Descending Apparatus (DA). Its is composed of a frame covered by a layer of material serving as a shield from heat developed in the process of deceleration and braking at entry into the terrestrial atmosphere with a velocity close to the second cosmic velocity.

Placed in this descending device are various instrumentations for conducting scientific measurements and also a radiocommunication app ratus, a thermoregulation system, with a power plant.

Instrument Compartment.(IC). Placed inside it are the radiotelemetric system, the apparatus for guigance by onboard means, the orientation and stabilization system, the rocket motive installation required for imparting the correcting impulse, the thermoregulation and power supply source. Optical sensors of the orientation system, solar battery panels and antennas are installed on the outside of the frame.

The program of scientific measurements of "ZOND-5" included further studies of physical conditions in the near-lunar space. A wide circle of scientific experiments was conducted in flight, linked with the operation of a series of onboard means, and verification of their operational capability over the path Earth-Moon-Earth. Tests were conducted in conditions of outer space flight of the orientation and motion guidance of the station. Tested also were the correcting motive installation and of guiding systems of low-thrust engines. During the conclusive stage of the flight, systems were operated, assuring the entry of the descending apparatus into the atmosphere with second cosmic velocity; tested also were the construction of the descending apparatus and the soft landing system. Tests of all radio-enginnering means were conducted in the course of the entire journey, alongside with measurements of trajectory parameters. It was also necessary to assure a high precision of guidance for apparatus' entry into the narrow corridor of the Earth's atmosphere. As is shown by the results of "ZOND-5" all this entire complex of problems was successfully resolved.

FLIGHT OF THE AUTOMATIC STATION "ZOND-5" ALONG THE PATH EARTH-MOON-EARTH.

The launching of ZOND-5 was achieved on 15 September at 0042 hours Moscow time. The station was placed into the orbit of the AES, alongside with the carrier rocket, with the following parameters:

../..

- the apogee is 219 km;
- the perigee is 187 km;
- the orbit inclination is 51.5°.

67 minutes after takeoff, on command from the program device switching on of the motive power was performed in order to correct the trajectory by an appropriate corrective thrust. As a result of this maneuver, the station passed to a new flight trajectory, allowing it to conduct physical investigations of the near-lunar space. At time of correction, the station was at a distance of about 325,000 km from Earth.

In accord with the flight program, the station flew past the Moon on 18 September at a distance of 1,950 km from its surface.

After flight around the Moon the station began to approach the Earth. Over this last flight trajectory control of onboard opertaional systems was conducted alongside with scientific investigations. As it approached the Earth further, a second trajectory correction took place, which ensured its reentry into the Earth's atmosphere with a preassigned descent angle. At the same time the flight velocity was lowered only by 0.005 percent, while the magnitude of the general aggregate impulse constituted about 0.35 m/sec.

One of the basic programs of flight consisted in the materialization of a precise entry of the station into the Earth's atmosphere with second cosmic velocity and its soft landing in a preassigned region.

ENTRY AND DESCENT OF THE APPARATUS IN THE EARTH'S ATMOSPHERE

The return of a spacecraft to Earth from flight around the Moon or any other planet of the solar system is an extremely complex problem, much more complex from the technical viewpoint than the return of AES, and it has a series of specific peculiarities.

In order to return sn interpanetary spacecraft to Earth with acceptable overloads, and, the more so, to effect a landing at a preassigned spot, the conditions of its entry into the atmosphere must be fulfilled with very high precision, namely the hitting of the computed spot at the required angle of descent.

With the view of obtaining the required conditions of aerodynamic braking one must approach the Earth at small angles, approximately along tangent and with such a calculation that its trajectory intersect only the upper layers of the atmosphere at maximum altitude above ground in a conditional perigee of about 35 - 45 kilometers.

Having an enormous velocity of the order of 11 km/sec, the station is sharply decelerated by the atmosphere, and quenches its speed in comparatively short time interval. At the altitude of about 7 km and at descent velocity of about 200 m/sec, the parachute system is deployed, facilitating the soft landing.

In order to effect the soft landing at a preassigned point, it is necessary to hold, as precisely as possible, the height of the conditional perigee (Fig.2). If the station had a perigee somewhat higher than the calculated one, it would begin to cross more rarefied layers of the atmosphere, decelerating less intensively, leading in the final count to a greater overflight relative to the preassigned landing spot. And, to the contrary, if the station should enter the atmosphere with lesser height of conditional perigee, it will be decelerated more intensively, effecting a landing short of the preassigned target place.

To what extent the accuracy of maintaining the conditional perigee affects the situation, that is, how precise is the station's hitting the atmosphere corridor, may be seen from the following example: the deflection of the conditional

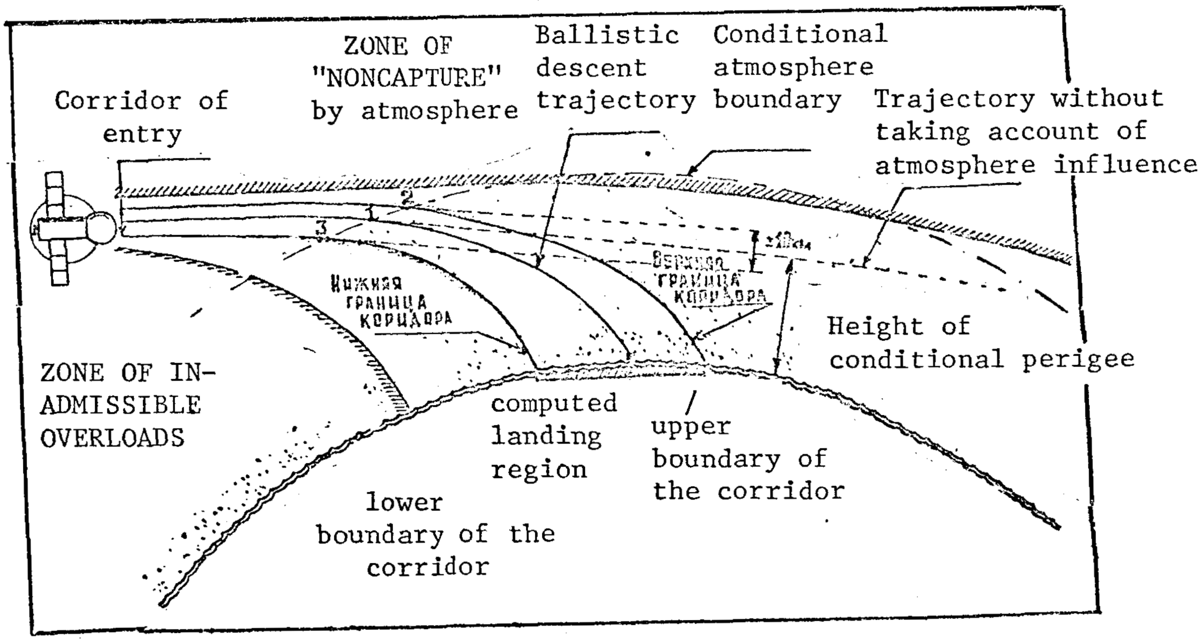


Fig.2

Fig.2. Entry of AS "ZOND-5" into the atmosphere and descent to Earth. 1) Calculated point of entry into the atmosphere. 2) Entry point in atmosphere with landing on the farther boundary of the assigned region. 3) Point of entry into the atmosphere with landing on the closer boundary of the preassigned region.

perigee by ±1 km in height results respectively in a deflection of the landing point by ±50 km for the height of conditional perigee of 35 kilometers. The increase in height of the latter by 25 km or its decrease by 10 km will result in the first case into total overflight of the Earth (by-passing the Earth), while in the second case the apparatus will be subject to overloads that may exceed the extreme admissible, and to intensive kinetic heating. For spacecrafts entering the atmosphere from an interplanetary trajectory, the most acceptable is the trajectory with entry angles of the order of 5 - 6 degrees to the local horizon plane with height of conditional perigee of 35 kilometers.

At the same time, in case of descent along a ballistic trajectory, during spacecraft's deceleration the overloads do not exceed 10 - 16 units. But if we increase the angle of entry by one degree, the value of the overload will increase to 30 - 40 units and may exceed that computed for the constrcution and the apparatus. On the other hand, the decrease of the angle of entry by one degree is dangerous on account of the possibility of "noncapture" os spacecraft by the atmosphere, i. e. it will by-pass the Earth and depart into the outer space, whereby only Earth's gravitational forces may hold it. Having described inder the action of gravitational forces an ellipse, the spacecraft will again return into the atmosphere, and will be able to "quench" its velocity and effect the landing only after multiple passings through its upper layers. But this increases by many factors the time of its sojourn in the near-terrestrial space and makes considerably more difficult its hitting the preassigned region.

Thus, the requirement of apparatus' landing in the preassigned region poses the condition of a very accurate approach to Earth's atmosphere. For example, in the case of "ZOND-5" the computed width of the "entry corridor" constituted 10 to 13 kilometers.

Comparing these figures with the scale of the flight trajectory around the Moon, the distance to which constituting some 385,000 kilometers, on may judge of the perfection and "apothecary" precision in the operation of the orientation systems and guidance of AS "ZOND-5".

The spacecraft returning to Earth after flight around the Moon has a velocity of 11 km/sec as comparad to 8 km/sec for the returning AES.

The passage of the dense layers of the atmosphere with second cosmic velocity induces substantially greater thermal overloads. A powerful shock wave raises ahead of a spacecraft entering with hypersonic velocity. Between the shock wave and the apparatus the temperature attains 13,000 degrees, as compared with the 7 to 8 thousand degrees during reentry with the first cosmic velocity. This influences essentially the magnitude of radiational thermal flows, which in this case exceeds over certain parts of the trajectory the magnitude of convective flows affecting the thermal conditions of descending apparatus' frame and the character of the streamline flow past it, which is quite substantially manifest on the stability of motion and precision in hitting the preassigned region.

Thus the problem of creating an optimum organization of thermal shielding is of great actuality. This problem is solved by the appropriate choice of the shape of the apparatus and its shielding by heat-proof material. The shape of the spacecraft may be of great variety.

Just as diversified will be the distribution of thermal overloads on the descended apparatus, which in its turn involves a corresponding construction of the heat-shielding material.

The successful return of the descending apparatus of ZOND-5 is evidence of the correctness of the selected shape and reliability of its construction, tested in real conditions.

Of great importance is the timely detection of the splashed down device and extraction from of the scientific apparatus and the films with the registrations of scientific measurements. This has been resolved by a special search-salvaging complex, equipped with the most perfect radioengineering means of detection. It was composed of sea-going vessels, reconnaissance aircrafts and helicopters.

*
* *

N.B. The general conclusion of this long article is along the line of the preceding comments by Prof. Sedov, Petrov etc.. with the usual praise for Soviet accomplishments and so forth.

*** T H E E N D ***

CONTRACT No.NAS-5-12487.
VOLT INFORMATION SCIENCES, INC.
1145 - 19th St.NW
WASHIGGTON D.C. 20036. Tel: 223-6700

Translated by ANDRE L. BRICHANT

on 29 - 30 Sept.1968.