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FROM SPACE ON A PARACHUTE

N. Lobanov

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16. Abstract

Improvements in the landing system of the Soyuz spacecraft are discussed. The system of parachutes is designed to guarantee a safe landing. The design attempts to cover all possible emergency situations. Selection of the landing area and time of ejection is an important aspect of safe descent.

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FROM SPACE ON A PARACHUTE

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In Response to Reader's Questions

Viewers who have watched the return of the cosmonauts to Earth on television usually see how smoothly the orange and white canopy of the parachute descends, and how the engines for the soft landing operate. This is only a small part of the very complex and important final stage of flight. /34*

The landing system for the Soyuz spacecraft consists of a main and a reserve chute which provide descent into the atmosphere and a rate of descent safe for the cosmonauts. The soft landing engines create comfortable conditions for landing. The shock absorbing devices mounted in the cosmonauts' armchairs facilitate this.

The requirements for this system are very serious; it must provide both a safe landing and recovery of the descent apparatus. The landing can occur on soft plowed land and on rocky soil. The height of the land area above sea level can differ considerably.

The parachute which is part of the landing system is the basic means for launching the space equipment into the atmosphere. Possessing many remarkable qualities, nevertheless it still has defects. The cosmonauts cannot control it during descent or select the landing section. The parachute cannot prevent an increase in the rate of descent in a descending flow of air and during strong winds on Earth. However, it would appear that ballistic experts can be of assistance here, specialists

*Numbers in the margin indicate pagination in the foreign text.

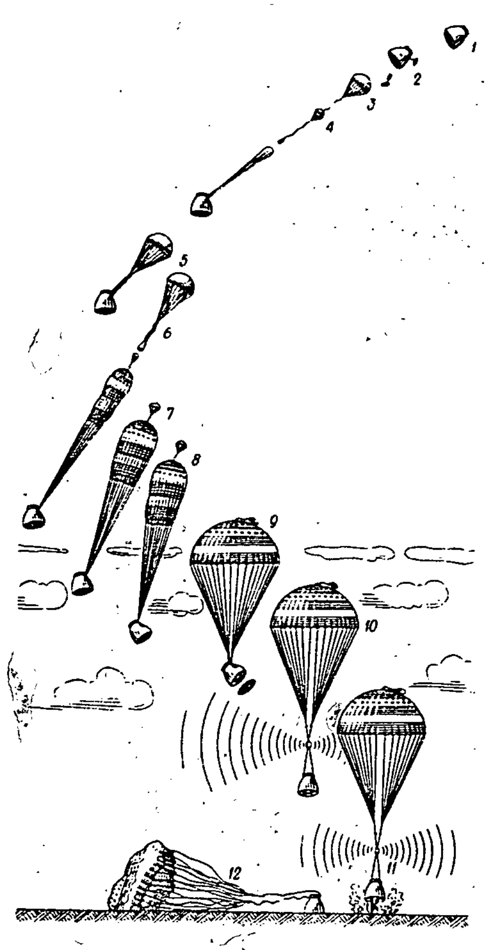

Diagram of operation of the main parachute system of the Soyuz spacecraft: 1--descent apparatus for the Soyuz craft; 2--firing the cover of the parachute container; 3--opened parachute, large area; 4--opened parachute, small area; 5--brake chute; 6--section of the brake parachute and entrance of the main chute; 7--partial filling of the reefed main parachute; 8--reefing of the main parachute; 9--section for drag protection; 10--hook for symmetrical suspension and switching on radio beacon; 11--switching on engine for soft landing; 12--uncoupling half the parachute shroudlines.

who calculate the descent of the spacecraft from orbit. Thanks to this calculation, the descent equipment can land in the most favorable conditions. If the calculations of these ballistic experts bring the spacecraft to a water surface, there is no danger, the conditions for landing on water are more favorable than on land. In truth, however, the evacuation of the cosmonauts becomes somewhat more complex.

The danger of dragging the equipment of the rigging parachute along the Earth is localized by the cosmonauts themselves who disconnect half of the shroudlines of the parachute from the suspension apparatus. As a result of this, the parachute is collapsed and loses its sailing properites. During strong winds on Earth, landing of the craft is changed and transferred to a more favorable time.

Preventing an increase in the rate of descent of the apparatus on the parachute in a descending flow of air in the ground layer is practically impossible. It is necessary to recognize the fact that it can increase from 6 to 8--9 meters per second and operation of the soft landing engines cannot create the required comfort; landing will be safe but fairly hard.

In principle, having increased the area of the parachute by two times, one can have a negative effect on the descending air flows but it is practically impossible to solve this problem: the parachute with such an area does not fit into the parachute container of the Soyuz spacecraft.

The area of the canopy of the main chute of the Soyuz equals 1000 m^2 and the volume of the parachute container is 0.3 cubic meters. The reserve parachute has an area 574 m^2 and is placed in a container with a volume 0.2 cubic meters.

Up until now, we have discussed the parachute as a means of landing but with return of the launch apparatus to Earth it also serves as a reliable means for braking in the atmosphere.

The rate of the descent apparatus rushing toward Earth is rapidly decreased as it penetrates the dense layers of the atmosphere and at an altitude of 12 km it amounts to 240 m/s. The area of resistance on the craft, adequate for effective braking at high altitudes and at high speeds, becomes inadequate at low altitudes. Therefore, at altitudes of 11 to 9 km, additional resistance must be activated, a braking chute. This occurs on command from the barometric instruments. The cover of the parachute container is ejected, ripcord chutes are opened which draws the braking chute with a total area of $14\ m^2$ from the container. The load affecting it is equal to the maximum allowable and therefore a large area parachute cannot be used under these conditions.

Having damped the rate of the apparatus to 90 m/s, the braking chute is drawn from the container of the main canopy which, being in a reefed condition is filled only partially so that the presecibed load is not exceeded. The partially filled parachute in 4 seconds slows the rate of the apparatus to 35 m/s, then spreads and is fully filled with air. Then, the load on the /35 parachute does not exceed the allowable size, 13 tons. In the process of filling the main parachute and with further descent of the equipment, speed is slowed to 6 m/s, that is, to a speed which provides safe landing.

Thus, the braking and the main parachutes slow the rate of the descent apparatus in three stages, from 240 to 6 m/s, providing a load on braking within maximum values tolerable to man.

After the main parachute is filled, the heat protection shield is ejected from the base section of the apparatus protecting the jet of the soft landing motor. Then, the parachute does not hang symmetrically as a result of which the apparatus deviates from a vertical position which is more desirable for landing. At a distance of approximately 1.5 meters from Earth, the soft landing engines are automatically switched on. At the end, the cosmonauts by pressing on knobs, release half of the shroudlines of the parachute from the descent apparatus thus preventing its dropping on the side and dragging along the earth with the sail parachute.

Safety in landing and recovery of the descent apparatus is provided not only by the improved design of the parachute system of the Soyuz but also by calculation of the unexpected situations which can occur during reentry from space.

For these reasons, we will assume, that the cover of the parachute container does not eject at a prescribed altitude and consequently, the main parachute does not operate successfully then. What happens in this case?

The automatic equipment gives the command for firing the cover of the container of the reserve parachute. It is true at a low altitude and at a relatively low speed of the descent apparatus. But why doesn't the braking parachute enter into the complex of the reserve parachute? The pulled parachute removes the reserve parachute immediately from the container. It is also in a reefed condition. After 4 seconds it is unreefed and filled completely.

The area of the reserve chute is almost twice as small as the main chute and therefore the rate of descent of the apparatus on the reserve chute at the moment the engine for the soft landing switches on reaches 8--11 m/s. The landing can be harder but still safe.

What happens if the braking parachute does not free the main chute from the parachute container?

This situation is possible with the assumption that the braking parachute fails or the main chute is wedged in a deformed container. Deformation of the container can occur with a sharp drop in air pressure which occurs at the moment the cover of the parachute container is fired. Then, inside the container, the pressure suddenly drops and becomes equal to atmospheric pressure and the external walls of the container inside the living section of the spacecraft are tested for a load of 10--11 tons per square surface meter. Depending on the altitude at which the cover of the parachute container is fired, the pressure drops and causes a load of 5--6 tons per square meter.

In this case, after 22 seconds from the moment the parachute opens, actuated by the braking parachute, it separates from the wedged main parachute and creats favorable circumstances for opening and operation of the reserve parachute.

The probability that the main chute will not fill is extremely small. Nevertheless, in such a case a device is planned which separates from the apparatus of the main chute in order to create conditions for subsequent opening and reliable operation of the reserve chute.

What happens if the engine for the soft landing does not switch on?

Failure of this unit in the landing system causes discomfort. Usually, in calm weather, landing of the descent craft on the parachute occurs at a rate of 6 m/s. With ascending air currents it decreases to 4 m/s. But with descending air currents, it amounts to 8--9 m/s. In the latter case, landing will be fairly hard. That is all.

As is well known, the parachute is also part of the safety equipment of the crew for emergencies on launching. When the spacecraft carrier deviates from the vertical at a certain angle the SAS [Smeshannoye aviatsionnoye soyedineniye, Composite air unit] orders switch on automatically; the spacecraft with the cosmonauts separates from the carrier and is carried to the side of the launch area at an altitude adequate for operation of a parachute. In this case, the low speed of the craft at the moment the parachute opens is compensated for by the large total area of the two open chutes whose drag reliably provides operation of the main chute. In ordinary conditions, at a high rate of speed of the spacecraft, the open parachute breaks off the connections calibrated for strength and is separated. Opening of the braking parachute provides secondary openings of a small area parachute.