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IN UNEXPECTED SITUATIONS: (COSMONAUT TRAINING)

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Translation of "V neshtatnoy situatsii," Aviatsiya i Kosmonavtika, No. 5, May 1976, pp. 40-41

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16. Abstract

Unexpected spacecraft flight situations are tackled by Ground Central backup crew and personnel running through simulated malfunctions on a spacecraft mockup, then radioing the recommendations to the orbiting crew. The joint US-USSR space flight is given as an example of emergency procedures followed in unexpected situations.

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IN UNEXPECTED SITUATIONS: (COSMONAUT TRAINING)

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[Article "V neshtatnoy situatsii" by N. Fefelev, major-engineer]

[Text] With every desire to take account of all situations that can crop up in a spacecraft in flight while in ground training, this is not possible. Even access to malfunctioning systems is not always feasible for the cosmonauts. This does not mean of course that the cosmonaut has to sit with hands folded and hope for a miracle. For each spacecraft, just like an aircraft, a set of procedures for detecting and localizing malfunctions is developed. Full mastery of this set of procedures and an excellent understanding of space technology aids cosmonauts in feeling that they are the true masters aboard the spacecraft or the orbital station.

However, without overstretching it, one can say that today there are no more complicated technical objects than a spacecraft or an orbital station. Each of them has tens of the most complex interacting systems and hundreds of instruments and units. Mastering them requires enormous efforts from cosmonauts and trainers and a scientific approach to organizing training. The prompt detection of malfunctions, trouble-shooting their causes and then correcting them are all stages on the ladder of the growing mastery of cosmonauts. By successively climbing the ladder, by the end of their training cosmonauts not only know to perfection the layout of the ship or the orbital station of the particular type, but also the details of operation of the systems of the spacecraft on which they are to fly. This takes several training sessions directly at the cosmodrome before the craft is launched.

But even during a flight Ground Control does not leave the crew without support. From the start of a flight a backup crew takes its place in an integrated trainer or a full-scale mockup of the spacecraft with operating equipment, where all the flight stages are reproduced and the full program carried out. When any difficulties show up in the actions of the cosmonauts in orbit or when malfunctions happen, it is here that recommendations are worked out for the crew. They are transmitted to the crew aboard the craft via the Flight Control Center.

Unexpected situations can arise for the most varied of reasons. And the kinds of these situations can be most different. There is nothing surprising in that such situations do crop up, of course: flights into space are a new field of human activity. Here the main thing is to come out of the difficulties that crop up with colors flying. And the cosmonauts have brilliantly coped with this. Here are a few examples.

The first television image from Soyuz 19 showed up on the screens of Flight Control Center 27 hours after the launch. At 19:34 hours Aleksey Leonov and Valeriy Kubasov began their first report from orbit to millions of television viewers. Everyone at the Center breathed deep sighs of relief.

This day there has been another reason for concern, a more serious one. The American astronauts had transmitted from the Apollo that they were completely unable to open the hatch of the docking module. Fortunately, it was possible to correct the second malfunction. The meeting of the ships and the cosmonauts of the USSR and the United States in orbit was held; it was viewed on the screens of television receivers by people all over the world.

Incidents happening on the Soyuz 19 and Apollo craft are examples of unexpected situations. So that is why they are called unexpected, because they were not anticipated by the flight programs. But unfortunately, they do happen, they complicate the crews' work and eat up a great deal of their energies and time budget, and further, often they make for a tense environment aboard the craft.

What happened during the joint flight of the Soviet and American ships posed no threat to the life of the cosmonauts, but still could have substantially affected the completion of the mission. Here is what it was.

Before Soyuz 19 had been inserted into a parking orbit for the rendezvous with Apollo, our cosmonauts had no opportunity to correct this malfunction: they had to perform the main task of the day. To do this they used specialists at Ground Control and while the crew was busy correcting the orbit, the specialists prepared recommendations for it. They closely looked at the possible reasons for the malfunction and outlined ways of correcting it. The [backup] crew on a Soyuz 19 mockup actually had to run through these operations and find the most rational sequence of steps, then pass their recommendations to space.

The Soyuz 19 crew was able to fix the onboard "television station" only after six in the evening, when the ship had already been inserted into the parking orbit. Aleksey Leonov and Valeriy Kubasov had to give up their sleep to eliminate the interference in the operation of the television equipment.

The situation was about the same on Apollo. Here Brand spotted a problem when, following the docking of the ship to the docking module in the second launch vehicle stage, he started to take apart the pin in order to free passage from the crew module to the docking module. It turned out that an improperly positioned connection of the explosive bolt device of one of the pin latches blocked the access of the tool with which the pin had to be removed.

And here as well Ground Control prompted Brand with a way out of the situation. Ground service specialists, having a duplicate of the docking pin and the same tool, thought about how to remove the cover for access to the connection and suspend it so that it did not interfere with the dismantling. Guided by their instructions, Brand lifted out the pin.

But as they say, there is many a slip between the cup and the lip. Eliminating the trouble in the docking pin forced the Apollo crew to drop two experiments planned for the second day of the flight, postponing them to a later time.

Due to their good training, the crews came out of the situations with flying colors.

From these examples we see that any unexpected situation happening in space has more than just a technical side. Any emergency aboard a craft, big or small, has a tremendous psychological effect on the crew and brings changes into how they live and work. So after each flight in which there was an unexpected situation, specialists carefully analyze the cause and kind of malfunction as well as what the cosmonauts did. This helps them to find out the characteristics of cosmonaut behavior in a complex situation. Then they can more purposefully prepare later crews for flights.

However, training cosmonauts on the ground and working to clear up malfunctions in an actual flight are far from the same thing. Cosmonauts have a great deal in common with pilots, in this respect. But while the training of a pilot continues even in the air, the cosmonaut thus far does not have this opportunity. But actually cosmonaut flight readiness must be no less than that of a pilot.

Experience in manned spaceflights shows us that their safety is most closely bound up with human efficiency. The complex nature of the effect of the extraordinary conditions and the preoccupation of the crew with the outcome of the flight, whose completion is still fraught with a certain degree of risk, sharply builds up the emotional tension. And this can fairly rapidly lead to crew fatigue and loss of crew efficiency. Any complication whatever during this period can be accompanied by nervous reactions and erroneous actions. That is why the behavior of cosmonauts in complex situations captures the fixed attention of researchers. Specialists have long studied how the human organism is affected by g-loads, oxygen starvation, acoustic noises, weightlessness and other flight factors. The results of these investigations have helped to uncover reserves of human efficiencies applied to the effect of each of these factors taken separately, but, sadly, they have not answered the question: how will they affect the human organism altogether, in a complex. And finding out the psychophysiological capabilities of man in unplanned situations of a spaceflight is a special complexity in itself. Here we are not only concerned with the fact that under ground conditions no extended period of weightlessness -- the most important spaceflight factor -- can be produced, but also we are interested in setting up the emotional tension, the risk that would induce the corresponding reactions in cosmonauts.

So during the training sessions attempts are made to build up an integrated model of a spaceflight by including in it elements that to some extent would make up for the lack of weightlessness and risk.

One such investigation, by a group of Soviet specialists, was reported at the 22nd World Congress on Aviation and Space Medicine[1].

Extremal conditions of human activity in several 10-day experiments were set up by simulating a spaceflight program with 2-day regime of continuous activity. How were the investigators guided in this?

In virtually any space flight there may be an incident when extended and most strenuous activity is required of the crew, without sleep or rest. The flight of the first expedition of the American orbital station Skylab can be taken as an example of this. Docking the Apollo with the station and repairing it took astronauts Conrad, Weiss and Corwin more than 27 hours of steady work. The crew of the American Apollo spacecraft, heading to the Moon, found themselves in an even more dangerous situation. For several days the astronauts and ground service specialists fought for the safe outcome of the flight.

The individual qualities of the crew members and the effectiveness of their training show up particularly strongly in these conditions; their psychophysiological reserves are vital.

There is another consideration underlying the plans of our experimenters: a 2- and even a 3-day period of work in a condition of forced alertness was not precluded in the activity of the ship crews in rescuing spacecraft that had suffered a misfortune in orbit.

To find out how a man behaves under these conditions, testers from different categories were brought in. The basis of the experiment was their continuous operator activity in 2-day and 8-hour duty shifts. Each duty shift had several watches: control, communication, stellar navigation and others. The program included mental, psychophysical, biochemical and clinical investigations as well as everyday-sanitary operations.

As to be expected, the efficiency of the testers during the first (adaptational) period fell; an increase in energy expenditures, slight, but predictable, was noted; the quality of tracking suffered, along with the accuracy of performing stellar navigation and meteorological tasks governing activity; the vision constants in perceiving signals dropped. As the assignments became more complicated, the adaptational period grew longer.

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[1] A. P. Grimak, V. I. Metlik, G. M. Kolesnikov, N. P. Fefelov, L. S. Khachatur'yants, Ye. V. Khrunov and Ye. M. Yuganov. "Investigation of Operational Efficiency of Cosmonaut in Conditions of Forced (Unplanned) Alertness."

Study of the activity of testers during this period was important also because in the first flight orbits the cosmonaut's organism also adapted to the new conditions. Cosmonauts can be in this state up to a day or longer. This causes the reliability of the human link in the control system to diminish. This fact had to be reckoned with in setting up the program of the tester activity in the first, most critical flight stage.

Cosmonauts in orbit of course do not know when and what the unexpected situation will occur onboard their craft and how long and continuously they will have to work. But the testers naturally did know and to some extent were ready for it. Nonetheless their heartbeat rose, their emotional tone dropped and their negative emotions built up. At once the number of errors in controlling the craft systems and in the stellar navigation measurements rose.

In the interests of improving cosmonaut flight training, it is important to know what role in the reliability of the test results is played by the motives and the interest of the participants in the experiments. To do this, one crew was made up of specialists from the Cosmonaut Training Center imeni Yu. A. Gagarin. This crew is headed by a cosmonaut. The other crew included only testers.

And this is what they found. During the 2-hour continuous duty shift, the testers were uninvolved in working for 2 to 3 minutes and then they themselves went back to working without outside intervention. They fell asleep for short periods during monotonous kinds of activity.

The members of the crew headed by the cosmonaut behaved differently. They worked purposefully and they carried out the "flight" program clearly. Fatigue was shown by a drop in the working rate in different kinds of investigations and by higher emotional tension: they conversed a great deal and joked a lot.

The hardest period of the 2-day continuous activity was the end of the first and the beginning of the second day. So they required stimulation. American specialists during the most critical flight stages offered pharmacological agents to their astronauts. For example, the crew of Apollo 13, on returning to Earth after its accident, were recommended stimulants after the last correction.

Different kinds of stimulants were tested in our experiments--from pharmacological agents to hypnosis. Hypnosis was used first for this purpose.

One of the crew members was in a state of induced hypnotic weightlessness from the beginning of the experiment. A day after the continuous duty shift, in the period most difficult for the testers, he was put into hypnotic sleep by radio, that is, without visible contact with the experimenter. He was told that he had not worked during the days elapsed so he did not want to sleep, he was full of energy. Awaking, the tester continued to work as if he had just come on the watch. The suggestion fully wiped out his fatigue and fought back his desire to sleep. The time of error-free operation at the telegraph key in his case, for example, more than doubled.

There is a different outcome for those crew members who had not taken stimulants. In performing tasks in stellar navigation, the number of errors and the time spent in measurements rose markedly by the end of their 2-day duty shift. All indicators spoke of a drop in their reliable efficiency as operators.

What conclusions were drawn from this study? First, the experimenters confirmed that the activity of an operator-cosmonaut during the first orbits of an orbital flight is complicated because of his organism making the transition to a new level of functioning. Second, a continuous 2-day operator duty can be entrusted to a person passing through the full complex of spaceflight training, considering, however, its character--complexity, workload and critical nature.

These experiments made it possible to scientifically substantiate earlier-noted failings in the performance of spacecraft crews, preparation of programs for forthcoming flights with greater confidence of success and introducing needed corrections into cosmonaut training, above all, naturally, into that portion of cosmonaut training that involves cosmonaut actions in unexpected situations.