

*Summary case history in telemetry analysis on a step in the Soviet manned flight program.*

## THE FAILURE OF COSMOS 57

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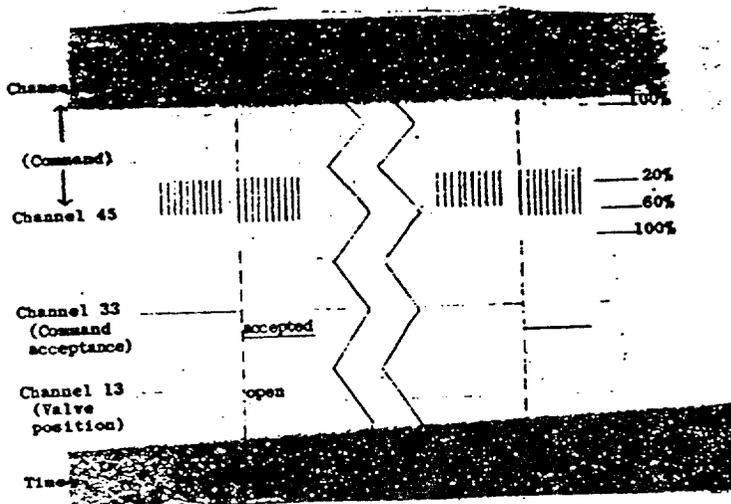
On 12 February 1965 the Soviets flew an unmanned test vehicle in their equivalent of the Gemini program. After being injected into orbit, Cosmos 57 was tracked for one revolution, but then its telemetry ceased and a whole covey of objects appeared on radar screens where it should have been. Five weeks later, 18-19 March, came the flight of Voskhod 2, from which cosmonaut Leonov stepped out through an airlock for man's first "walk" in space. It became clear that Cosmos 57 had been an automatic prototype of the Voskhod 2, flown primarily to test the operation of the airlock. Finding out what went wrong with the test and why its failure did not delay Voskhod 2 has been an interesting exercise.

### *Tests and Telemetry*

Testing the airlock would entail the performance of a number of operations on ground command—deploying the chamber as an extrusion from the spacecraft, opening and closing the outer hatch, pressurizing the chamber by opening a valve from the cabin, closing that valve, opening and closing the inner hatch, opening and closing an airlock vent valve, repressurizing with compressed air, and jettisoning the airlock before retrofire. It was possible for U.S. investigators, by comparative study of the Cosmos 57 and Voskhod 2 telemetry with previous take, to identify the data associated with most of these airlock operations, both the ground commands and the action

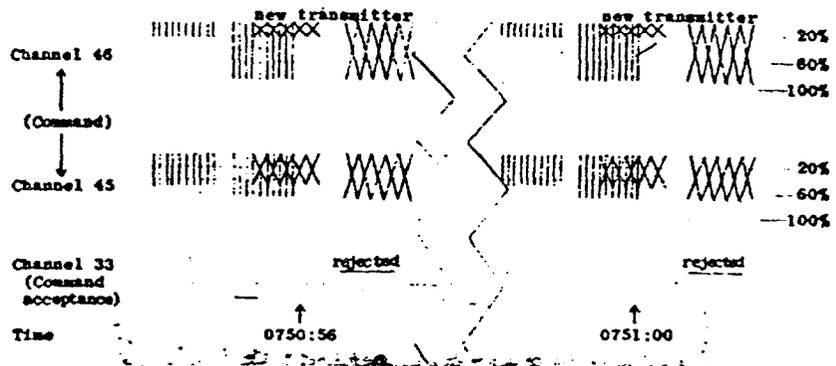
monitors on the spacecraft. The command codes and action indicators for other spacecraft operations could be determined from earlier experience. The important ones of these latter for our purposes here are the indicator showing that a ground command has been accepted and two indicators reflecting activation of descent system programmers, which arrange attitude and retrofire at the proper moment to land in the recovery area on next opportunity.

Cosmos 57 was launched at 0730 GMT. Our telemetry records of the flight begin about 17 minutes later. The airlock is already deployed, and a test of opening and closing the outer hatch is in progress. At 0748:36 the hatch is closed. The next step is to pressurize the chamber by opening a valve from the main cabin. The ground command channels are 46 and 45, and the code for opening this valve consists of two successive pulses at respectively 20% and 85% of band width on channel 46 simultaneous with two at 50% and 65% of band width on channel 45. This command is given at 0750:47; a downward pulse on channel 33 coinciding with the second pair of command pulses shows that it is accepted; and a change in the valve position indicator on channel 13 confirms that the valve has opened. A graphic enhancement of these telemetry traces looks like this:



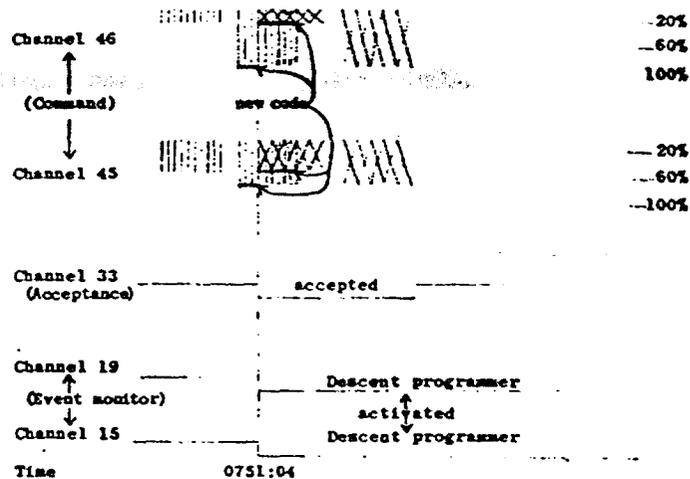
*Hazard of Redundancy*

Pressure monitors soon show that air pressure in the cabin and airlock have reached equilibrium at about 0.7 atmospheres, but the controlling transmitter, in accordance with the Soviet practice of sending commands in series, continues to repeat the valve-open code every four seconds. Two such redundant commands are registered in downward pulses on channel 33 as accepted by the spacecraft. After that, however, the telemetry traces on channels 46 and 45 become irregular, with fragmentary command pulses, which upward pulses on channel 33 show are rejected. Reconstruction from the fragments shows that another identical series of commands is being superimposed, out of phase, on the first. Clearly a second ground transmitter, not synchronized, is beginning to take over control as the first one passes out of range. The reconstructed signals can be illustrated thus:



Then at 0751:04 channel 33 shows acceptance of a command triggered by the *first* of the two pairs of pulses from the new transmitter. Apparently signal strengths at this moment were such that the spacecraft took the second pair from the old transmitter followed by the first from the new to form another code, actually the mirror image of the valve-open command. Moreover, it recognized the synthetic code as the one—or close enough to it—which was to command that programming for retrofire begin, because the descent system monitors on both channels 19 and 15 show displacement downward. (Voskhod 2 would similarly start both systems at the same

time, though previous flights had not.) The traces of these simultaneous events are seen below:



*Over and Out*

The readings on channels 19 and 15 should have told the Soviet control that the flight would abort at the end of the first revolution and so have given time to forestall the programmed retrofire, but the controllers apparently failed to recognize the situation until the spacecraft had passed beyond range of countercommand. (Here is a hazard they accept in confining control stations to their own territory.) When we pick up the telemetry again the airlock is still attached and pressurized, but a reading on channel 43 gives the pressure in the retro bottle as almost gone and regular oscillations in the spacecraft's radio signal strength show it to be tumbling some 78 times a minute. Evidently retrofire had occurred with improper orientation for descent, either because of inadequate timer data accumulated so early in the flight or because of the eccentric mass of the unjettisoned airlock.

Nevertheless the Soviets went through with one more test operation. At 0904:40 channels 46 and 45 carry a command to close the valve whose redundant order to open had brought about this trouble,

channel 33 signifies acceptance, and the channel 13 position indicator moves back where it was. Of the required tests only those involved in refilling the chamber with compressed air, opening and closing the inner hatch, and jettisoning the airlock have not been performed. At this juncture a destruct system incorporated into the spacecraft seems to have been activated.

Presumably because the trouble would have been spotted and corrected by the crew of a manned craft, and because all the airlock operations could in fact be carried out manually, the space-walk flight of Voskhod 2 was not delayed.