

MANUAL CONTROL IN SPACE
RESEARCH ON PERCEPTUAL-MOTOR FUNCTIONS
UNDER ZERO GRAVITY CONDITIONS
L-10

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Are human abilities to control vehicles and other machines the same in space as those on Earth? The L-10 Manual Control Experiment of FMPT started from this question.

Suppose a pilot has the task to align the head of a space vehicle toward a target. His actions are to look at the target, to determine the vehicle movement, and to operate the manipulator. If the activity of the nervous system were the same as on Earth, the movements of the eye and hand would become excessive because the muscles do not have to oppose gravity. The timing and amount of movement must be arranged for appropriate actions. The sensation of motion would also be affected by the loss of gravity because the mechanism of the otolith, the major acceleration sensor, depends on gravity. The possible instability of the sensation of direction may cause mistakes in the direction of control of manipulator movement. Thus, the experimental data can be used for designing man-machine systems in space, as well as for investigation of physiological mechanisms.

In this experiment, the direction of vehicle heading is expressed by a light spot of an array of light emitting diodes and the manipulator is of a finger stick type. As the light spot moves up and down, the Japanese Payload Specialist, as the subject, must move the manipulator forward

and backward to keep the movement of the light spot within the neighborhood of the central point of the display. The position of the light spot is computed in such a manner that when the stick is kept at the neutral position, the light spot moves randomly, and that when the manipulator is deflected from the neutral position, a motion whose acceleration is proportional to the angle of deflection is added to the movement of the light spot.

The Operator Describing Function, which is an expression of human control characteristics, can be calculated from 2 minutes of raw data of the light spot position and stick deflection. The 2 minutes of operation is called a run, and 8 runs with resting periods composes a session.

The on-orbit experiment will be conducted on the second, fourth, and seventh days. One session of experiment on each of these days is conducted following the L-4 experiment, which uses the same apparatus. The Payload Specialist, aided by a Mission Specialist, will take our apparatus from a rack container, set up the apparatus, attach electrodes for measurements of eye movement and muscle activity, conduct the L-4 Visual Stability Experiment, conduct one session of the manual control experiment, and then disassemble and stow the apparatus.

In addition to the flight experiment, pre-flight and post-flight experiments will be conducted. The data of three sessions on orbit will reflect adaptation of physiological systems to microgravity. The data of post-flight experiments, on the other hand, will reflect re-adaptation of physiological systems to the gravity condition on the ground. Control data collected with and without psychological tension will be scheduled just prior to and long before launch.

Expected Results

Automation such as automatic control systems for vehicles, robots for industrial manufacturing, etc., is rapidly developing. The more automation develops, however, the more understanding of human abilities becomes necessary. In space activities, automation is being performed when feasible, however, it has also been realized that system performance, safety, and efficiency is largely enhanced by use of human activity at appropriate system interfaces.

The investigation of manual control in space is expected to lead to development of man-machine systems with higher performances and safety and with lower costs. If phenomena such as frequent mistakes in direction and/or close correlation between the Operator Describing Function and adaptation of physiological systems to the space environment is found, it would be an important cue to understanding the mechanism of such adaptation.

