Ground-Based Reduced-Gravity Facilities

For the past 30 years, NASA Lewis Research Center's ground-based reduced-gravity facilities have supported numerous investigations for several research disciplines. Lewis' two drop towers and its DC-9 aircraft have provided a low-gravity environment (gravitational levels that range from 1 percent of Earth's gravitational acceleration to one-millionth of that measured at the Earth's surface) for brief periods of time. "Zero gravity," the weightless condition also known as microgravity, can be produced in these facilities by creating a free-fall or semi-free-fall condition where the force of gravity on an experiment is offset by its linear acceleration during a "fall" (a drop in a tower or a parabolic maneuver by an aircraft). The low-gravity environment obtained "on the ground" in NASA facilities is the same as that of a spacecraft in orbit around the Earth.

Even though ground-based facilities offer relatively short experiment times (a few seconds to 20 seconds), they have advanced our scientific understanding of many phenomena. In addition, many experiments scheduled to fly on sounding rockets, NASA's fleet of space shuttles, the Mir space station, and the International Space Station have been tested and validated in these ground facilities prior to testing in space. Experimental studies in low-gravity environments can provide new discoveries and advance our fundamental understanding of science. Many tests performed in NASA's facilities, particularly in the disciplines of combustion science and fluid physics, have resulted in exciting findings.

NASA Lewis' facilities host scientists and engineers, both domestic and foreign, from universities and Government agencies. In a typical year, well over 100 microgravity experiments are supported by these unique national resources. The following paragraphs highlight the accomplishments of these facilities for just the past year.

Lewis' DC-9 aircraft, our largest reduced-gravity platform, can accommodate several experiments during a flight. Pilots can obtain low-gravity conditions of approximately 20 seconds by flying a parabolic trajectory that includes a rapid climb at about 55° to 60°, a slow pushover at the top of the climb, and descent of about 30° to 40°. During the course of this maneuver, an altitude change of approximately 6000 ft is experienced. Over 50 of these maneuvers can be performed on a single flight.

Astronaut crew training performed onboard Lewis' DC-9 aircraft in preparation for the Microgravity Science Laboratory missions flown on the Space Shuttle Columbia in April and July of 1997.

Lewis' DC-9 continued to play a key role in microgravity research in 1997, with 73 flights that totaled 180 flight hours and 3313 trajectories while supporting 38 investigations, many of which involved multiple flights. Astronaut crews trained for several experiments that flew on STS-83 and STS-94, and the president of the Canadian Space Agency, William Evans, and the Canadian Minister of Industry, John Manly, participated in research flights that included experiments sponsored by the Canadian Space Agency. These milestones were all reached before the DC-9 was eliminated from the microgravity program on July 21. Future reduced-gravity aircraft flights will be performed on NASA Johnson Space Center's KC-135 aircraft. Six to twelve KC-135 flight campaigns will be conducted out of Lewis every year with this aircraft.

Lewis' 2.2-Second Drop Tower obviously offers a shorter test time than the DC-9, but because of its simple mode of operation and its ability to perform several tests per day, it is an attractive and highly utilized test facility, particularly for performing evaluation and feasibility tests. Over 16,000 tests have been performed in this drop tower to date. During fiscal year 1997, as in the past several years, drop tests averaged about 100 per month.

The top of the drag shield is lowered into position over a combustion experiment from the University of Michigan prior to a test in Lewis' 2.2-Second Drop Tower.

In the 2.2-Second Drop Tower, reduced-gravity conditions are created by dropping an experiment in an enclosure known as a drag shield to isolate the test hardware from aerodynamic drag during a 24-m free fall in the open environment. Over 30 experiments were supported during the 1200 drops performed in fiscal year 1997. As in the past, several of these experiments were preliminary tests of space shuttle experiments. The steady utilization of this drop tower is envisioned to continue since many new experiments are in the design and fabrication phases of development for the coming years.

The Zero Gravity Research Facility, a registered U.S. National landmark, provides a very clean low-gravity environment for 5.18 sec as experiments are dropped 132 m in a vacuum chamber. The aerodynamic drag on the free-falling experiment is nearly eliminated by dropping it in a vacuum. This procedure restricts drop tests in this facility to two per day. However, the relatively long test time and excellent low-gravity conditions more than compensate for the lower test throughput rate. Because of these operating conditions, this facility usually supports fewer projects than Lewis' other facilities. In fiscal year 1997, seven major projects were supported as 130 test drops were executed.

Lewis contacts: Jack F. Lekan (2.2 Second Drop Tower), (216) 433-3459, John.F.Lekan@grc.nasa.gov; Dennis M. Thompson (Zero-Gravity Research Facility), (216) 433-5485, Dennis.M.Thompson@grc.nasa.gov; and Eric S. Neumann (Reduced Gravity Aircraft Operations), (216) 433-2608, Eric.S.Neumann@grc.nasa.gov
Authors: Jack F. Lekan, Eric S. Neumann, and Dennis M. Thompson
Headquarters program office: OLMSA
Programs/Projects: HEDS, Microgravity Science, STS, Mir, ISS