SMALL SCALE DROP TOWER PROTOTYPE
DESIGN AND DEVELOPMENT
J Willis
Western Aerospace Centre Prize Competition (2010)

Abstract
With the advancement of technologies such as air breathing hybrid rocket engines and reusable space planes, commercial stratospheric and extra-atmospheric aviation is becoming a closer reality. The use of such technologies is the next logical progression towards minimizing the impact that current aviation practices have on the environment. ‘Space hopping’ vehicles will drastically cut the flight time of long haul travel while the associated liquid propellant propulsion methods will virtually eliminate the emissions that are currently produced by the aviation industry. Such developments have prompted the need for research into the effects of short term exposure to microgravity on human physiology as well as other physical phenomena. While there are a number of technologies available to facilitate terrestrial and extraterrestrial research into this area, there remains little in the way of a low-cost ground based facility that can provide a quick, repeatable process for testing microgravity phenomena prior to full scale extra-atmospheric tests aboard space based research facilities.

This project focuses on developing a small scale prototype of such a facility that could be produced at a lower cost than current conventional methods and provide a quick turnaround of trials.

In order to achieve a microgravity environment within the Earths atmosphere, the test subject must be isolated from the effects of air resistance and dropped or propelled at a rate equivalent to the acceleration due to gravity. The preferred method of achieving this is through the use of a drop tower, consisting of a vertical shaft down which the test subject is allowed to freefall enclosed in an aerodynamic drag shield to counteract the effects of air resistance. Some towers may also be sealed and evacuated to further reduce air resistance. A prolonged period of microgravity can be achieved by propelling the subject in a parabolic path, similar to that of the European Space Agency’s Airbus A300 parabolic test aircraft.
The chosen solution for this project is the development of a 2m drop tower that rivals the operational capability of much larger towers by utilising a novel method of propelling the test capsule. The use of a computer controlled linear motor allows the user to precisely control the velocity of the test capsule at any point during operation and eliminates the requirement for the long reset time seen by current facilities. By propelling the capsule in a parabolic velocity path up and down the length of the 2m tower, a period of 1.1 seconds of microgravity can be achieved, the equivalent of a 9m high conventional drop tower.

One factor that has a large impact on the height of conventional towers is the need for a large decelerator at the base of the tower to prevent damage to the test capsule. These decelerators normally take the form of a large air bag or polystyrene ball container, which can constitute up to 40% of the height of the tower. By utilising the linear motor as an acceleration and deceleration device, as little as 15% of the tower height is required to stop the capsule without causing damage to the test subject. The elimination of these large decelerators is also integral to the rapid turnaround time achievable by this design, which is only limited by the speed at which an experiment can be installed or reset. Experiments that do not require resetting can be run continuously, vastly increasing the scope of research that can be undertaken.

The prototype tower is completely self contained, to allow the facility to be used as a teaching aid, and includes a control module into which the desired velocity profile can be uploaded via computer. The advantage of using a pre-calculated velocity profile for the linear motor is that varying degrees of microgravity can be created, simulating environments at varying altitudes as well as recreating lunar or Martian gravity conditions. As the capsule is permanently powered during ‘flight’, there is no need to provide an evacuated operating space as air resistance can be calculated into the velocity profile and overcome by the motor, reducing the cost and complexity of the tower considerably.

This solution significantly improves on the functionality of previous drop tower designs, allowing a wider range of applications without the need to alter the basic operating process of the tower and thus allowing researchers a much greater degree of flexibility when studying microgravity effects.