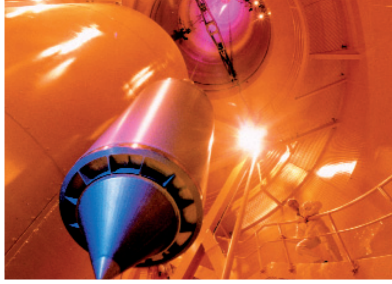
Space Technology on Earth

The Bremen Drop Tower is a ground-based laboratory for short-term microgravity experiments. It is a unique facility in Europe that attracts scientists from all over the world. In comparison to orbital systems it represents an economic alternative with permanent access. Since its inauguration in September 1990 the concrete shaft of a height of 146 m has become the landmark on the Bremen University campus.

The Drop Tower serves as an important supplement to either existing or planned orbital or suborbital platforms for microgravity research. About 400 drop experiments each year have successfully been carried out since. The facility delivers 4.74 s of near weightlessness up to three times a day. In December 2004 Bremen celebrated the first shot of the catapult system, which achieves to double the microgravity time by conducting a vertical parabolic flight. This construction has been developed at ZARM and offers world-wide unique research conditions. •

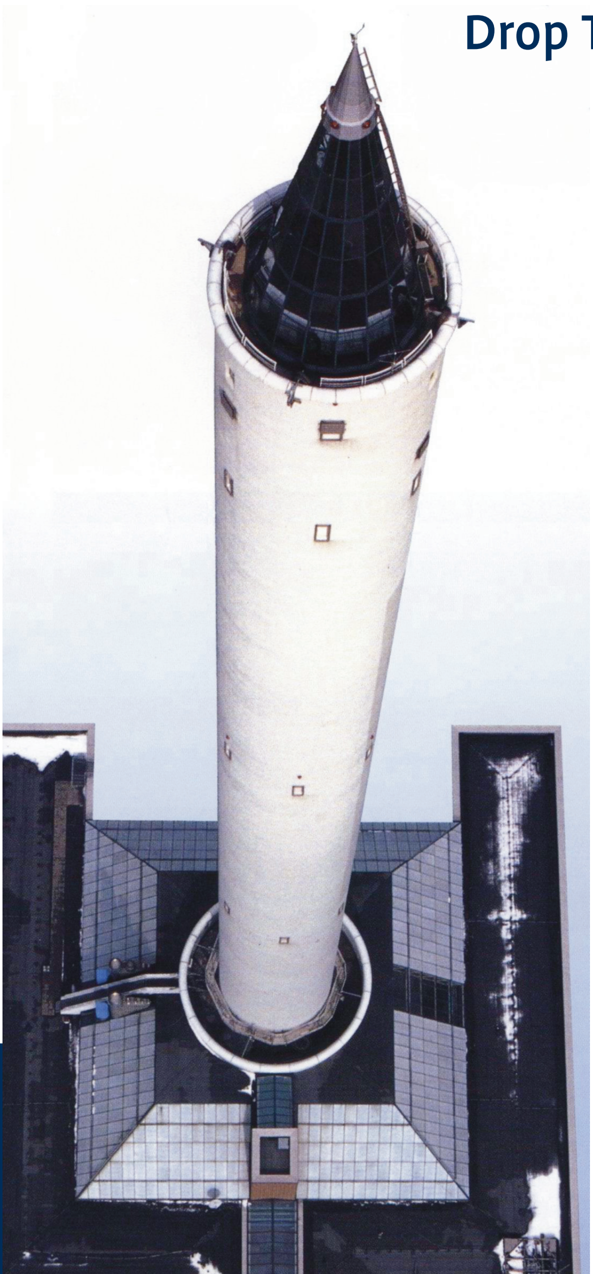


Picture 1
The picture shows a drop capsule prepared for an experiment. It will be pulled up to a height of 120 m inside the drop tube. Afterwards the deceleration unit in the background will swing back underneath the tube. The tip of the capsule is only required for the dynamic stabilization during the braking period.

The Bremen Drop Tower

ZARM

Drop Tower Functionality



The microgravity laboratory system itself is a cylindrical capsule with a diameter of 800mm and a length of 1.6m or 2.4m depending on the space required for experimental studies. Inserted platforms, held in aluminium profiles, form a modular drop capsule structure. The standard equipment of a drop capsule includes a computer platform as well as the accumulator platform necessary for internal power supply. The computer of the drop capsule will facilitate experimental control, data storage and interactive experimental guidance by means of telemetry during pre-test and microgravity phase.

The whole capsule will be closed pressure-tight with an aluminium cover after the integration of the experiment. The actual steel drop tube has no connection to its surrounding tower and stands at a height of 13 meters on the thick roof of the deceleration chamber. It is eccentrically arranged to the vertical axis of the concrete tower. This way, the transfer of wind-induced tower oscillations to the sensitive experimental operation can be excluded to the greatest possible extent even under the typically changeable Bremen weather conditions. The drop capsule is pulled up by a winch to a height of 120 meters. Afterwards, the tube, designed as a vacuum unit, will be closed pressure-tight. Now the 1,700 cubic meters capacity of the tube and the deceleration chamber is evacuated to

Picture 2
With a height of 146m the Bremen Drop Tower is the central unit of the ZARM Institute.

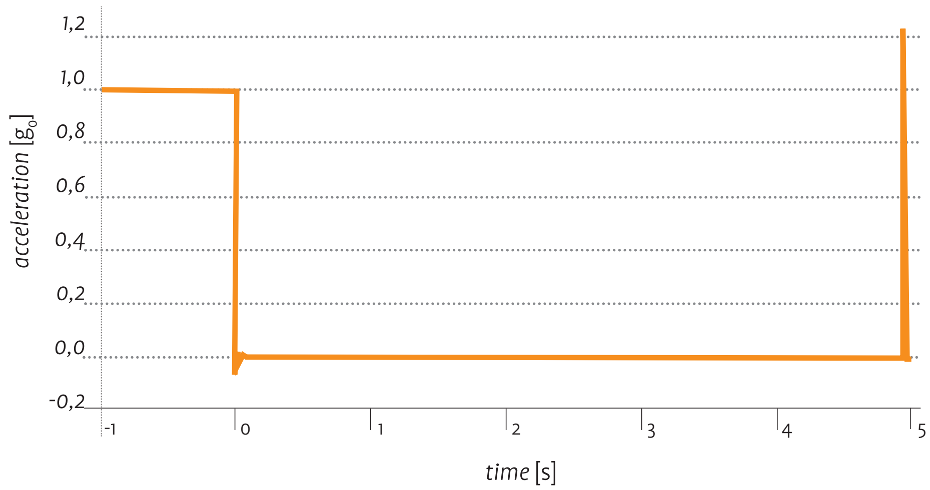
How to achieve weightlessness

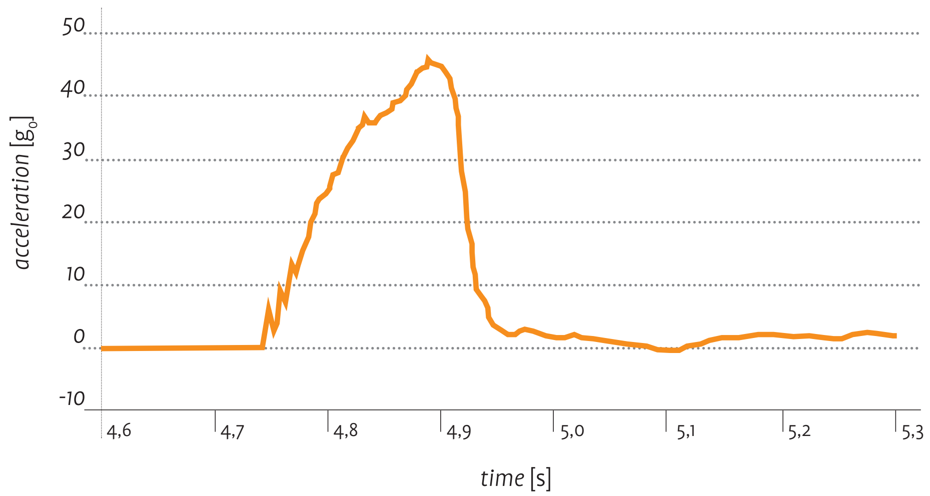
If there are no outer accelerations measurable inside a laboratory system, it is called weightless. In order to achieve this state of weightlessness the capsule has to move on paths that are feasible in the gravity field of the earth without propulsion. In this case, inertial force will compensate gravitational force. Compensation will be more or less favourable depending on different external influences. At the Bremen drop tower the quality of weightlessness achieved is one millionth of the Earth's gravity. •

to minimize the air drag acting to the falling capsule. A system of altogether 18 pumps with a nominal capacity of 32,000 cubic meters per hour requires about 2 hours for the evacuation. The capsule is then released in accordance with the scientists and their experiments at a residual pressure of 10 Pa (1Pa = 10^{-5} bar) by the control station of the drop tower. After the initial disturbances caused by the release have been damped down, residual accelerations of merely 10^{-6} g_0 can be detected during the free fall of 110 meters in a simple drop experiment.

The excellent microgravity quality achieved at the Drop Tower Bremen exceeds that of manned orbital platforms by orders of magnitude. The drop capsule arriving at the braking zone with a final speed of 167 km/h is gently stopped inside the deceleration container. The container is filled with fine polystyrene pellets. The nose cone of the capsule reduces the entry peak and stabilises the vertical axis during braking . For retrieval, the vacuum chamber is reflooded with preconditioned air within 20 minutes. Then, the experiments as well as the results are immediately at the scientists' disposal. •

Picture 3
In the ZARM integration hall a drop capsule has been prepared with an experiment and is now on its way into the drop tube in the background.





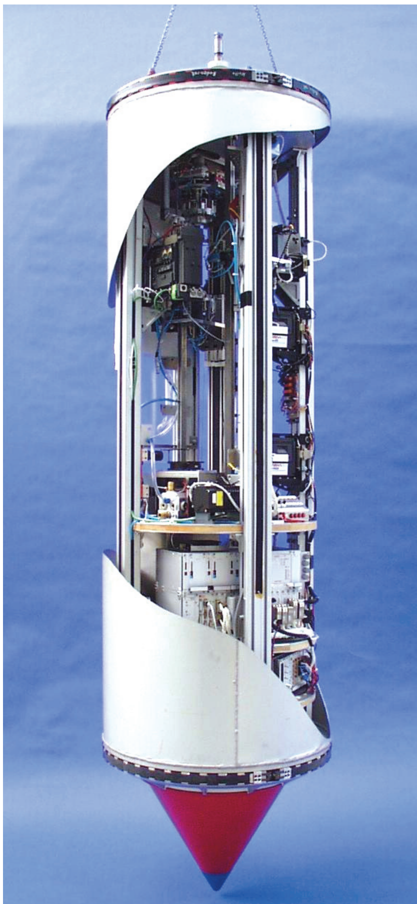
Picture 4
The first diagram shows the residual acceleration occurring in the drop capsule at time of release and the following phase of weightlessness as a function of time.

The second diagram plots the deceleration of the gravity capsule at a speed of 167 km/h when entering the breaking unit, filled with polystyrene pellets. With 30 g_0 in average the deceleration is so soft, that even sensitive devices stay undamaged.

The Experiments

Up to now, experiments have been conducted in the field of fluid physics, rheology, combustion, thermodynamics, materials science and biotechnology. The investigation of gravity-dependent phenomena is relevant for basic research as well as terrestrial application. To utilize the Bremen drop tower, scientists are equipped with platforms in advance to be able to prepare the experimental set-up at their own premises. Final integration into the drop bus and adaptation of electrical and electronic interfaces is accomplished at Bremen. •

Picture 5
The experiments and the complete diagnostic system are installed in the drop capsule structure.



Picture 6
Pressure tanks of the catapult system

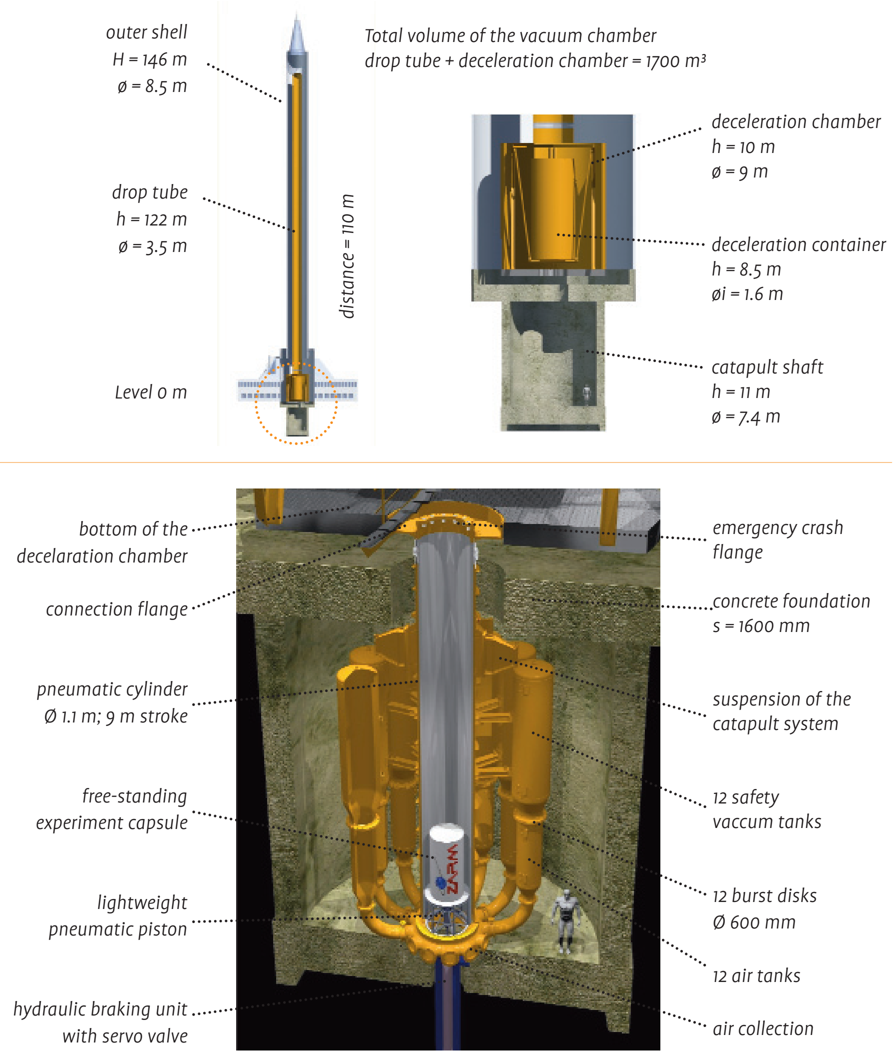
The Catapult System

Since turning the first sod on May 3rd, 1988, the future installation of the catapult system had been taken into account by building the necessary chamber under the tower. With the inauguration of the catapult system in December 2004, ZARM entered a new dimension of ground-based microgravity research. This world novelty will meet scientists' demand of extending the experiment period to more than 9.5 seconds.

In order to achieve this doubled experiment time the catapult system has been installed at the shaft of the tower. It is located in a chamber 10 m below the base of the tower. This chamber is almost completely occupied by twelve huge pressure tanks. These tanks are placed around the elongation of the vacuum chamber of the drop tube. The pneumatic piston in its centre accelerates the drop capsule by the pressure difference between the vacuum inside the drop tube and the pressure inside the tanks. The acceleration level is adjusted by means of a servo-hydraulic braking system controlling the piston velocity. After only a quarter of a second the drop capsule achieves its lift-off speed of 175 km/h. With this exact speed, the capsule rises up to the top of the tower and afterwards falls down again into the deceleration unit which has been moved under the drop tube in the meantime.

This catapult system accelerates capsule masses from 300 kg up to 500 kg to a speed of 48 m/s within 0.28 seconds. A drop tower of approximately 500 m would be necessary to achieve the same experiment time of 9.5 seconds as it is available now in the Drop Tower Bremen.

Views of the Drop Tower System



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