ORBIT – Air Bearing Facility for Free Floating Contact Dynamics Experiments

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Introduction

The critical combination of dynamic contact between robotic systems and the field of GNC, has become an increasingly important aspect of European space missions. Capture of uncooperative targets for Active Debris Removal (in the framework of the Cleanspace initiative) as well as landing and sampling on low-gravity bodies, such as comets, asteroids, and small moons present such a combination. The purpose of the ORBIT facility is to support the development of existing and upcoming missions, as well as R&D activities in these high-visibility technology fields.

This poster showcases the capabilities of a flat floor facility at ESA ESTEC and its associated systems, referred to as the Orbital Robotics Bench for Integrated Technology (ORBIT). This facility provides a suitable analogue to the microgravity space environment, albeit constrained to two dimensions.

The focus areas of the facility are testing of close-range rendezvous, docking, berthing of free-floating objects, and landing or drilling on low-gravity bodies. The ORBIT facility is also available to external parties for independent testing activities.

Objectives

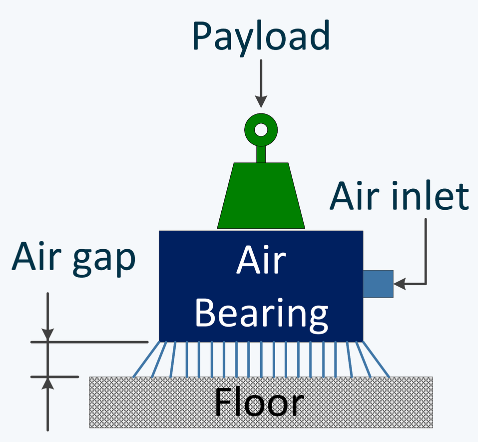
- Provide realistic free floating dynamics similar to the microgravity space environment in a reduced set of degrees of freedom.
- Maintain the technical competence of the section staff by working on state-of-the-art microgravity systems.
- Prototype and test new ideas, perform shadow engineering to industrial work, and generally support on-going and future industrial R&D activities via testing support and expert advice.

Floating platforms

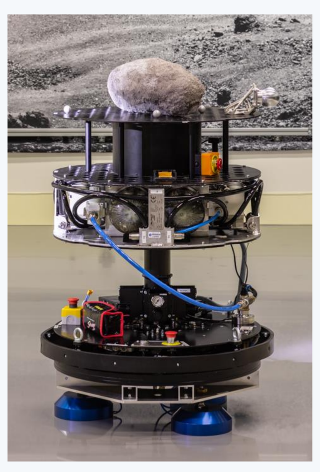
- **REACSA**: 200 kg platform with 50 kg payload capacity. Actuated by eight air thrusters and one reaction wheel. 100 kg payload capacity when used passively floating without actuators.
- **MANTIS**: 35 kg passively floating air bearing platform with 100 kg payload capacity. Air propellers can be added for actuation.

Working principle

- Friction reduction is achieved by creating a stable air gap between air bearings/cushions and the extremely flat floor.
- The payload is placed on top of the air bearing platform, which consists of the air bearings/cushions and the pneumatic system.
- Compressed air is stored locally on the platform or is provided by a continuous air supply.
- Strict requirements on the floor in terms of flatness, inclination and surface roughness are necessary to avoid drift and friction of the air bearing platform.



Air bearing working principle

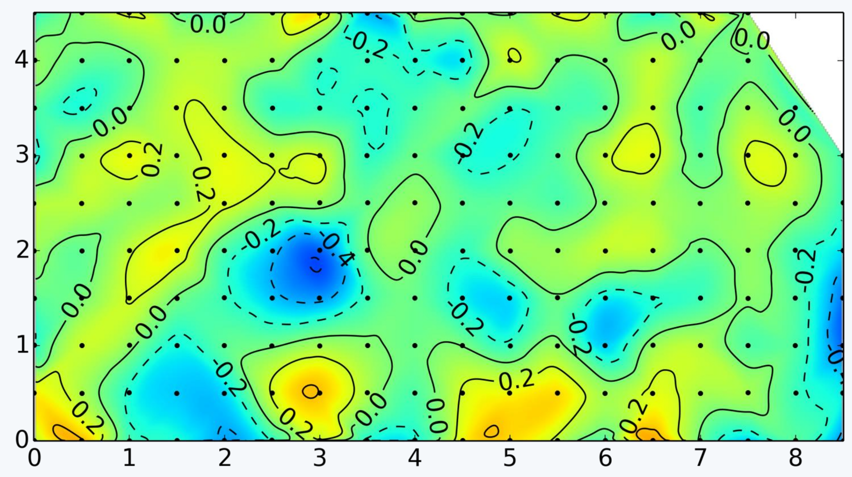


REACSA: 200 kg actuated floating platform

Facility description

Floor characteristics

Size: **4.8 m x 9 m.**
Overall flatness: **< 0.8 (± 0.1) mm.**
Maximum inclination: **< 0.3 mm/m.**



ORBIT flatness map (in mm)

Absolute motion tracking system

VICON motion tracking system with 44 cameras covering the entire working volume with **sub-millimetre precision**.

Universal mounting points

Three rows of 45 mm Bosch-Rexroth **aluminium profiles** for mounting items to the walls (planetary surface mock-ups, etc.).

Overview of the ORBIT facility

Pressurised gas installations

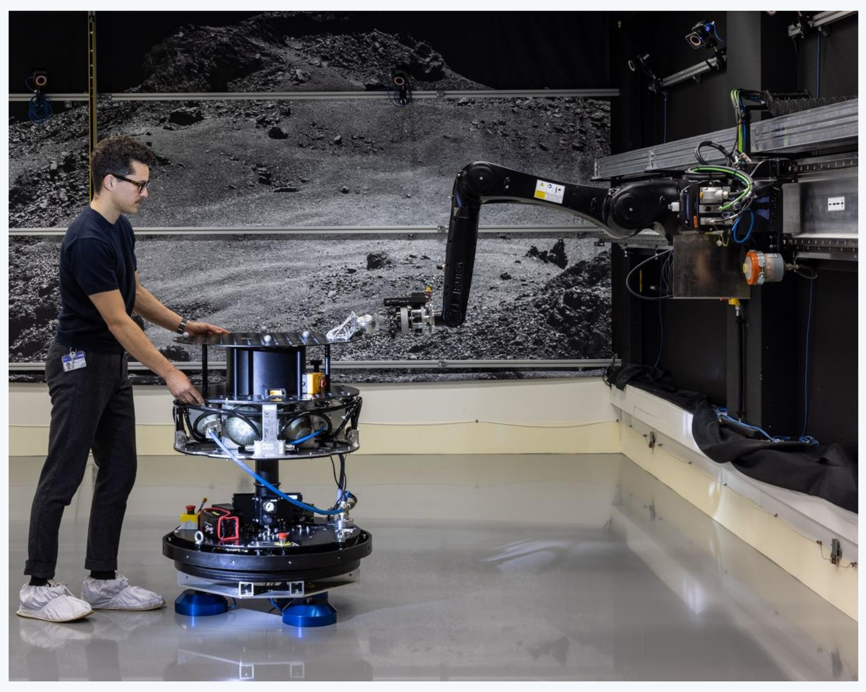
Pressurised **nitrogen outlet.**
Flow and pressure (0 – 7.5 bar) **controlled air outlets** for continuous air supply.
300 bar **air compressor.**

Crane

A semi-automatic **jib crane** for lifting items up to 250 kg onto the floor.

Overhead camera

Live video capture with a camera installed on the ceiling of the laboratory, covering the floor workspace up to a **height of 1 m.**



Interaction between floating platform and robotic arm

Robotic arm interaction

Rail-mounted KUKA KR10 robotic arm with reach into the floor workspace for complex manipulation and steering of floating platforms.

Ejection mechanism

An automated linear ejection mechanism for **launching floating platforms** throughout the floor at defined speeds

Current activities

Active Debris Removal (ADR):

ClearSpace-1 Capture System Full Scale Test. ESA is providing continuous engineering support to ClearSpace to advance the Technology Readiness Level of the ClearSpace-1 capture system. ORBIT is being used for various full-scale sub-system tests and contact dynamics characterisation.

Rendezvous and Docking (RvD):

Docking and gripper system testing. ESA is providing the infrastructure and technical expertise to enable the testing of docking and gripper systems in a frictionless 2D environment.

Multi-body dynamics research using a compliant docking module (GIMLI). GIMLI consists of a spherical passive docking interface paired with a compliant active docking module, weighting under 4.5 kg. This allows the compliant linkage of different robotics systems to enable multi-body experiments.

Satellite position and attitude control system design:

REACSA controller. The largest floating platform in the ORBIT facility is actuated by eight air thrusters and a reaction wheel. Its software stack is developed for modularity with the ability to use arbitrary controllers and benchmark their relative performances. The ACS is used by academic partners to test novel controller architectures in an experimental setting or correlate simulation results.

MANTIS propeller platform. The small floating platform in the ORBIT facility can be actuated by eight air propellers. Effective control of the platform with air propellers is a challenging control task that provides an exciting learning experience for control engineers. The control of the platform enables complex test scenarios in the ORBIT floor.