ORBIT - A Facility for Experiments on Free Floating Contact Dynamics

European Space Agency
Agence spatiale européenne

Hendrik Kolvenbach, Kjetil Wormnes

Automation and Robotics Section, ESA ESTEC, Noordwijk

Introduction

The critical combination of robotics dynamic contact and guidance, navigation, and control (GNC) have become an increasingly important aspect of European space missions. Capture of uncooperative targets for Active Debris Removal (in the framework of Clean Space initiative) as well as landing and sampling on low-gravity bodies such as comets, asteroids and small moons present such combination. To support the development of existing and upcoming missions as well as R&D activities in these high-visibility, technological fields, the need for upgrading the verification capabilities of the Automation and Robotics (A&R) laboratory to better accommodate robotics and GNC activities has become apparent.

This poster describes the development of a flat floor, referred to as the Orbital Robotics Bench for Integrated Technology (ORBIT), being one critical part of enhancement to existing infrastructure to allow free floating contact dynamics. This provides a suitable analogue to the space environment, albeit constrained to two dimensions.

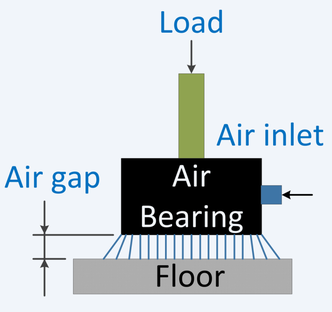
The facility is initially intended to support existing work happening in the GNC and robotics laboratories, to test close-range rendezvous, docking, berthing of free-floating objects and landing or drilling on low-gravity bodies, but with the intention to also offer it for other applications both internally and to industry down the track.

Objectives

- Provide realistic free floating (contact) dynamics similar to the space environment in a reduced set of Degrees of Freedom.
- Foster the maintenance of technical competence for the section staff.
- Prototype new ideas, perform shadow engineering to industrial work and generally support on-going and future industrial R&D activities.

Working principle

- Friction reduction is achieved by creating a stable air gap between air bearings/cushions and the floor.
- The payload is placed on top of the air bearing platform. The air bearing platform consists of the air bearings/cushions and the pneumatic system.
- Air is stored locally on the platform or is provided by a continuous air supply.
- Though 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

Experimental air bearing platform

Facility description

Floor characterisation:

- Size**: 4.8 m x 9 m.**
- Overall flatness: **< 0.8 (± 0.1) mm.**
- Maximum inclination: **< 0.3 mm/m.**
- Roughness: **RA < 0.9 µm, RQ < 0.6 µm, RZ < 1.8 µm.**

Absolute motion tracking system:

- The floor is in the field of view of **12 Vicon Bonita-10** cameras for absolute motion tracking.

Mounting profiles:

- Three rows of 45 mm Bosch-Rexroth **aluminum profiles** for mounting of additional items to the wall (planetary surface mockups, etc.) are located on three sides of the facility.

Gas installations:

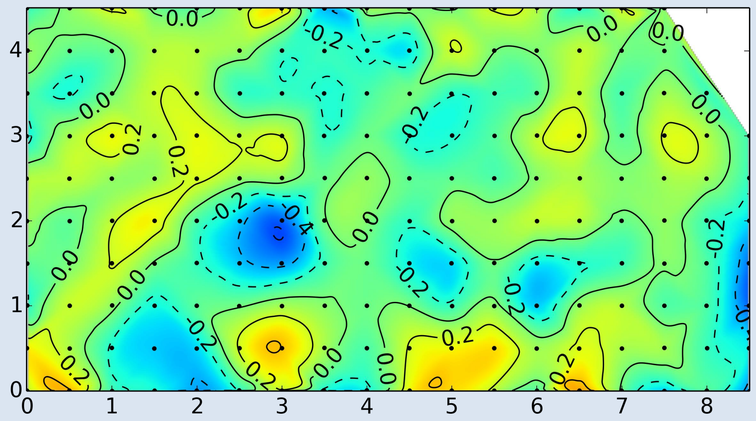
- Pressurised **nitrogen outlet.**
- Flow and Pressure (0 – 8 bar) **controlled air outlets** for continuous air supply.
- 200/300 bar **air compressor.**

Jib crane:

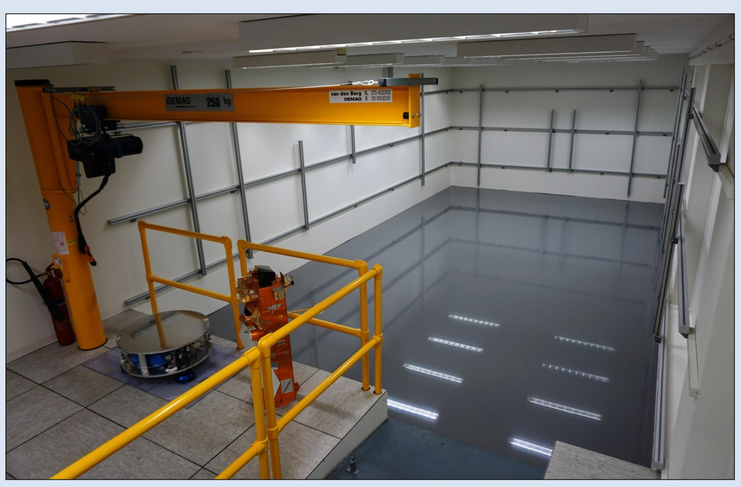
- A semi-automatic **jib crane** for lifting items up to 250 kg on the floor.

Workstations:

- **Workplaces** to perform mechanical and electrical prototyping work are located near the facility.



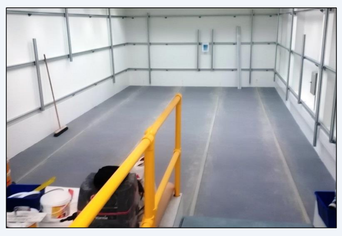
Flatness map of the ORBIT floor (in mm)



Overview of the ORBIT facility

Floor creation

The creation of the floor had demanding requirements in terms of flatness, inclination and roughness and required pouring different materials in several steps. Each step had to be validated by an absolute position laser scanner to detect misalignments (Leica AT402). When a misalignment was detected, the floor was corrected and measured again before proceeding to the next step.



Step 1: Creation of "dikes" where the top defines a levelled, horizontal plane.

Step 2: Pouring of levelling concrete between the "dikes".

Step 3: Pouring of the first layer of epoxy for sealing the concrete and levelling.

Step 4: Pouring of the final epoxy layer for precise levelling and smooth surface finish.

On-going / initiated activities

On-orbit servicing (OOS) and Active Debris Removal (ADR) : e.Deorbit, d.Deorbit

- ***PLATFORM-ART, ESTEC ORBIT Facility cross-validation.*** This on-going activity is cross-validating the representation of contact dynamics in the ORBIT facility and the PLATFORM-ART facility at GMV, Spain, by operating the two in an overlapping regime (constrained to 3DOF and lower speeds).
- ***Validation of momentum transfers when using nets for ADR capture.*** Two nearly completed TRP contracts have developed validated dynamics simulators for ADR. The ORBIT facility will be used to extend the validation by investigating momentum transfer.
- ***Validation of momentum transfers when using harpoons for ADR capture.*** As part of a running GSTP activity to raise the TRL of harpoons for ADR, it is intended to use ORBIT for investigation of momentum transfer during the impact between the target and the harpoon.
- ***Autonomy and control approach for grasping free-floating objects.*** The aim is to test and gain valuable information about grasping a free-floating satellite autonomously. Hardware procurement has been initiated.
- ***Applicability of VIMANCO to ADR.*** VIMANCO is a software for visual servoing developed under a concluded TRP contract. This activity aims at clearly understanding the requirements for adapting the software to aid in the capture of space debris or orbital servicing targets.

Landing and operating on low-gravity bodies : PHOOTPRINT

- Drilling on a low gravity body is investigated in the frame of an ongoing activity on a high-precision granite air-bearing table. On its conclusion ORBIT will be used to perform the experiment on a different scale, where it is also possible to include in the testing the landing (GNC and mechanics) and subsequent hold-down operation.