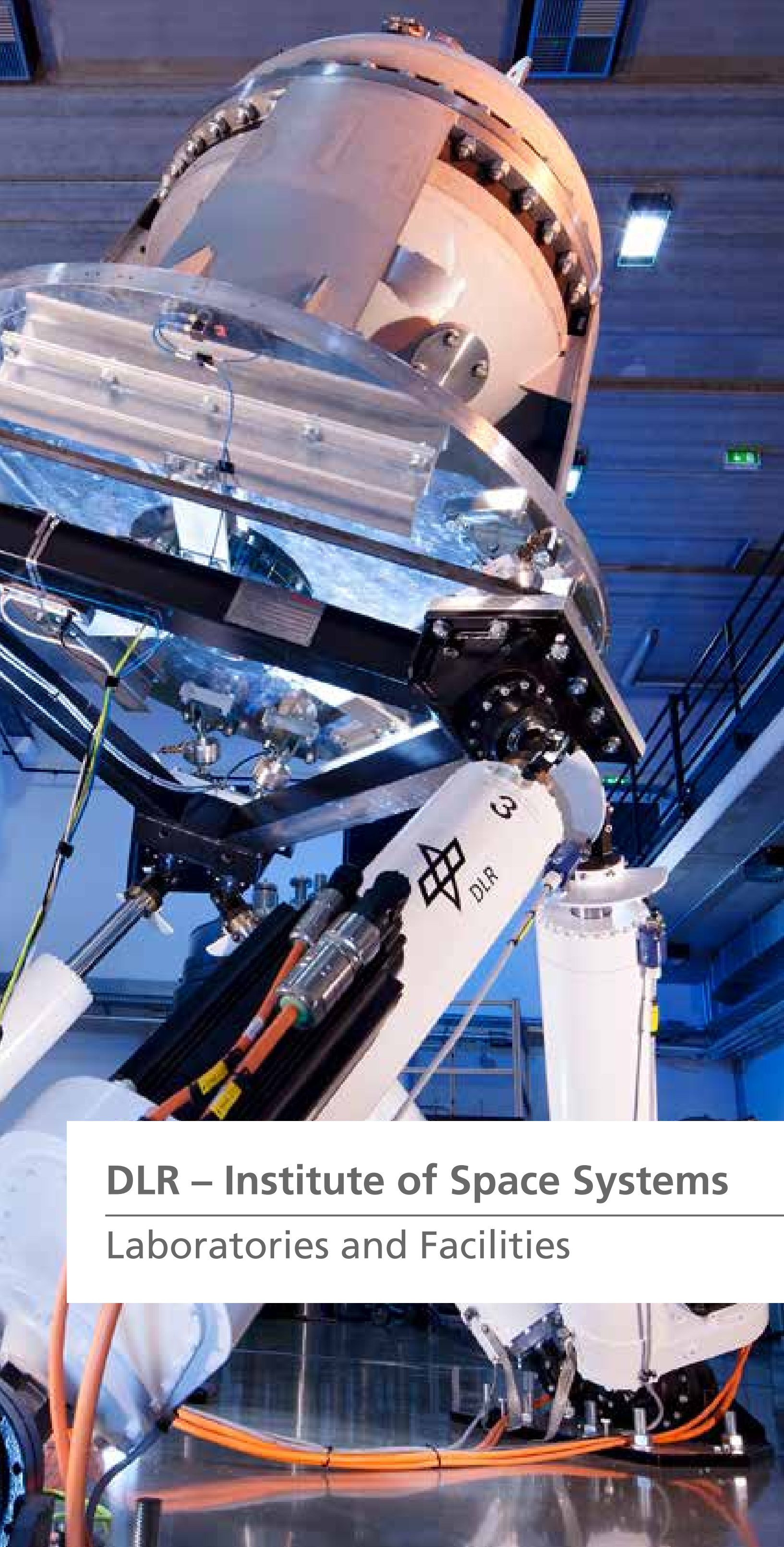


DLR – Institute of Space Systems

Laboratories and Facilities

Contents

Institute of Space Systems

The Institute of Space Systems in Bremen designs and analyses possible future spacecraft and space missions (launchers, orbital and exploration systems, satellites) and assesses them in terms of their technical performance and cost. The Institute relies on modern methods of multidisciplinary engineering for its systems design and analysis that include, among other things, a computerized system for concurrent design.

In addition, the Institute of Space Systems develops, builds and operates its own spacecraft and missions for scientific research and technology demonstration in the fields of small satellites and planetary landing craft in cooperation with other DLR institutes and research institutions. As a competence centre for system engineering and being specialized in system design, system integration and system testing, the Institute has a coordinating and integrating role in the development process.

To make future space missions possible or to improve existing technologies in terms of performance, the Institute of Space Systems conducts research into relevant system technologies with a focus on the behaviour and influence of cryogenic fuels in tanks, landing technologies, attitude and orbit control systems, avionics systems and high-precision optical measurement systems.

To learn more, please visit **DLR.de/irs/en**

Entrance of the Institute of Space Systems

Mechanical-Dynamical Test Facilities

Space structures are exposed to intense, quasi-static, dynamical-mechanical and transient loads, particularly during launch. The test laboratory is responsible for the qualification of components and systems for space applications by simulating vibrations and pyroshocks generated during launch. The results are also used for the verification, validation and correlation of structural analyses. To qualify flight hardware, the laboratory is operated as class ISO-8 clean room and is accredited according to DIN EN ISO/IEC 17025:2018. The laboratory contains two vibration shakers and one pyroshock test facility.

Pyroshock

The pyroshock test facilities enable space components and systems to be qualified during simulations of intense transient excitation caused by pyrotechnic ignitions (pyroshocks). The ‚ringing plate' method is used in this process. An aluminium plate (the ringing plate) and the adapted test object on the plate are excited to vibrate at high frequencies by an intense and very short impulse. The shock plate, together with the entire test structure, can be individually adapted for a certain main response frequency.

dlr.de/irs/en/pyroshock

Technical Data

- Mounting: on Aluminium shock plate
- Excitation: nail gun, pendulum hammer
- SRS Levels: up to 26,000 g in SRS
- Specimen Weight: ≤30 kg
- Accredited according to DIN EN ISO/IEC 17025:2018
- Modal parameter identification

Pyroshock test facility during shock initiation

Vibration Test Facilities

The vibration test facility consists of two electro-magnetic shakers, one with a nominal force of 11 kN and one with a nominal force of 89 kN. The capacity of the 11 kN shaker allows for testing of components and systems of the Nano-Satellites class. The 89 kN shaker allows for testing of components and systems of the Compact Satellites class with a weight up to 500 kg.

Vibration:
- Sinusoidal test and resonance survey test
- Random vibration test
- Quasi-static loads test at low-frequency sinusoidal excitation
- Sine burst

Shock:
- Half-sine shock pulse
- Saw-tooth shock pulse
- SRS shock similar to a pyroshock

dlr.de/irs/en/shaker

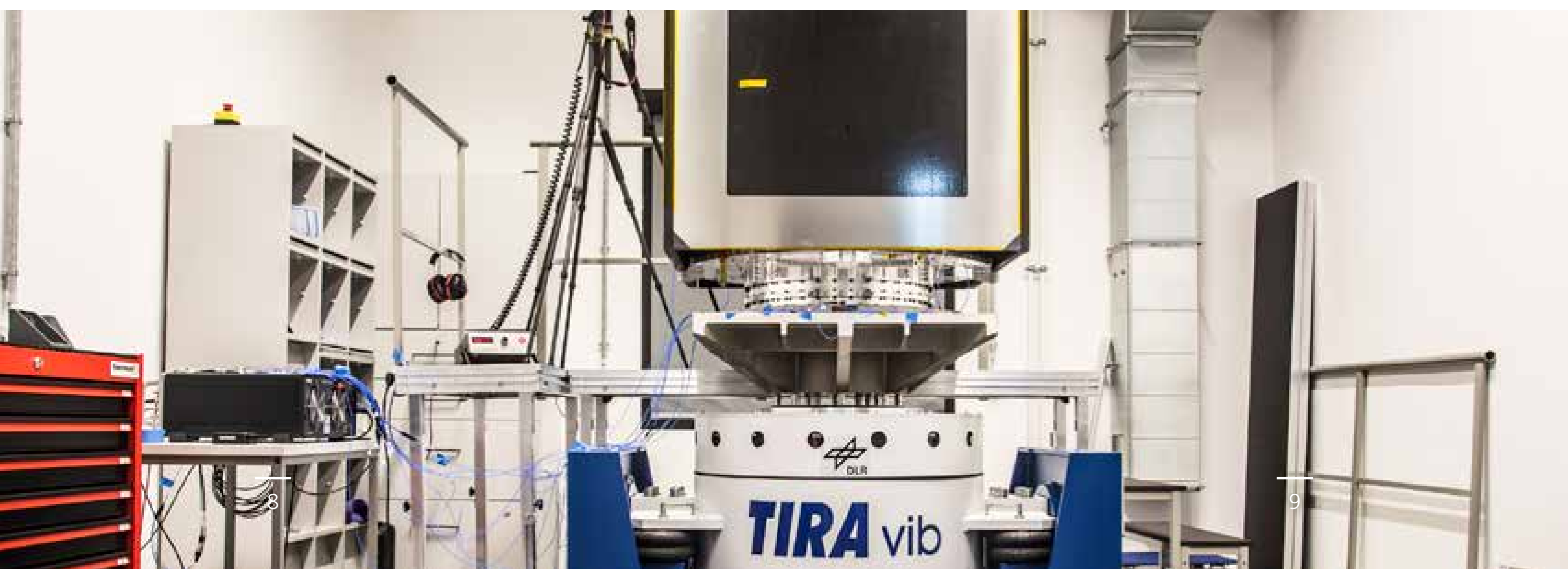
11 kN Vibration Test Facility (air cooled)

• Nominal force:	11000 N
• Max. test weight:	130 kg
• Frequency band:	3 Hz – 3000 Hz
• Max. acceleration:	957 m/s²
• Max. stroke:	51 mm
• Cleanliness:	Class ISO-8 clean room
• Accreditation:	DIN EN ISO/IEC 17025:2018

89 kN Vibration Test Facility (water cooled)

Technical Parameters:	**Sine**	**Random**	**Shock**
• Nominal force (kN):	89	89	267
• Max. acceleration (m/s²):	981	883	2450
• Max. velocity (m/s):	2	2	3.5
• Max. stroke (peak to peak; mm):	63.5	63.5	76.2
• Max. test weight:	970 kg on armature 2200 kg on slip table		
• Frequency band:	5 Hz – 2000 Hz		
• Cleanliness:	Class ISO-8 clean room		
• Accreditation:	DIN EN ISO/IEC 17025:2018		

89 kN Vibration Test Facility



Solar-Thermal-Vacuum Test Facilities

The Solar-Thermal-Vacuum Test Facilities serve for thermal vacuum testing of both individual components and overall systems for space applications. The aim of the thermal vacuum test is to support the process of designing space components and thermal control systems, their qualification and the verification of numerical thermal models. The environmental conditions that will be encountered in space, such as high vacuum, the cold temperature in space and solar radiation, can all be simulated in the Space Simulation Chamber and the Sun Simulation Chamber.

Using a special test setup the Space Simulation Facility can be used to study the venting behaviour of structures during launch. The solar simulation chamber is accredited as a testing laboratory in accordance with DIN EN ISO/IEC 17025:2018 and fulfils the clean room requirements of ISO-8 in accordance with Standard ISO 14644-1.

dlr.de/irs/en/wsa

Open Space Simulation Chamber

Space Simulation Chamber

TQCM contamination control:

• Available length:	3.50
• Available width/height:	2.1m / 1.6m
• Volume:	ca. 17m^3

Vacuum system:

• End pressure at 22°C:	10^{-6} mbar

Thermal Shroud:

• Max. temperature:	390K (approx. 120°C)
• Min. temperature:	80K (-190°C)

Solar simulator:

• Power:	0.5 – 1.4 kW/m^2
• Approximate irradiated area:	1m^2
• Spectrum:	0.2 – 2.5 µm
• Collimation angle:	± 2°

Temperature Control Plate:

• with thermostat:	210K - 380K (~ -60°C – 110°C)
• with gas mix system:	80K - 380K (~ -70°C – 110°C)

Measurement system:

• Number of measurement channels:	80
• Measuring range:	20mV, 60mV, 200mV, 2V, 6V, 20V
• DC:	73K to 573K (-200°C to 300°C)
• Thermocouples:	PT100
• Customer feed through:	4 x SUB-D 9, 3 x SUB-D 15, 3 x SUB-D 25, 1 x SUB-D 37, 4 x SUB-D 50

Venting pressure change:

- 75mbar/s for 2 seconds
- 50mbar/s for 6 seconds
- 30mbar/s for 12 seconds

Sun Simulation Chamber

Chamber:
- Volume: 0.8 m^3
- Available length: 0.8 m
- Usable diameter: 0.45 m
- Pressure: 10^{-7} – 10^{-6} mbar
- Temperature range: 93 K – 393 K (-180 °C – 120 °C)
- Temperature control: Electrical, thermostat and liquid nitrogen

Solar simulator:
- Heat flux 0.9 – 1.4 kW/m^2
- Illuminated diameter ca. 100mm
- Spectrum 0.2 – 2.5 µm

Measurement system:
- Number of measurement channels: 80
- Measuring range: 20mV, 60mV, 200mV, 2V, 6V, 20V
- DC: 73K to 573K (-200°C to 300°C)
- Thermocouples: PT100

dlr.de/irs/en/ssa

Climate Chamber

In the climate test laboratory environmental influences like temperature and humidity, on a test object can be simulated under ambient pressure. It allows for varying temperature and humidity levels over time. This is an important part of operational tests for electronics and mechanical components, as it ensures that the flight hardware is also capable of withstanding required environmental conditions on Earth. The scope of the laboratory also includes the conditioning of test objects, the sterilization of space components for interplanetary missions, as well as the qualification of applications for use on Earth.

The climate laboratory is accredited as a testing laboratory in accordance with DIN EN ISO/IEC 17025:2018 and fulfils the clean room requirements of ISO-8 in accordance with Standard ISO 14644-1.

dlr.de/irs/en/klimapruefung

Technical Data

- Available volume: 600 l
- Dimensions (L/W/H): 800mm / 760mm / 950mm
- Allowed weight of test object: 160 kg
- Temperature range: ~200K – 450K (-70°C – 180°C)
- Speed of temperature change: Cooling 2.5 K/min, Heating 4.0 K/min
- Relative humidity: 1% – 98% (gN_2 <10%)
- Atmosphere: Air, gaseous nitrogen
- Feed through: 1 x Ø125 mm, 1 x Ø50 mm

Complex Irradiation Facility

The Complex Irradiation Facility (CIF) is used for experimental research into the degradation of materials under simulated space radiation conditions as those found beyond that of low Earth orbits. Three light sources and a proton/electron dual beam accelerator are connected to an irradiation chamber where the samples can be exposed to a precisely defined dose of electromagnetic radiation (IR, visible light, UV and VUV), as well as electrons and protons The energy from the protons and electrons, which can amount up to 100 keV, enables a penetration depth of a few micrometres, depending on the sample material.

This allows the in-depth study of the main degradation effects on the sample's surface area. The facility is set up with ultra-high vacuum technology performed with metal gaskets without organic components. This prevents self-contamination, which could influence the results of the experiments.

dlr.de/irs/en/kobe

Technical Data

Proton-/ Electron dual beam accelerator

- Current in lower energetic range (2.5 – 10 keV): 1 – 100 nA
- Current in higher energetic range (10 – 100 keV): 0.1 – 100 µA

Light source:

- Solar simulator: 200 – 2150 nm (2700 W/m², AM0, class B)
- Deuterium UV source: 112 – 400 nm (2.8 W/m²)
- Argon VUV source: 40 – 410 nm (58 mW/m²)

The Complex Irradiation Facility (CIF)

Ultra-High-Vacuum Laboratory

All materials outgas as soon as they are exposed to a vacuum. Outgassing greatly depends on the material and its conditioning, the operating temperature and the time spent in vacuum. For space applications, outgassing can lead to serious problems, particularly when part of the released gas condenses onto an adjacent surface. The qualification of all materials used with regard to outgassing is therefore of utmost importance when developing hardware for use in space. This also applies to materials that are used in vacuum facilities for testing flight hardware, and which could lead to contaminations before the start of the actual mission.
The UHV (Ultra-High-Vacuum)-Laboratory contains the UHV- and the M-VCM-facility designed for investigation of outgassing of materials and parts and the resulting risk of contamination.

Micro-VCM Facility

The Micro-VCM-Facility is used for outgassing tests in accordance with the ESA standard ECSS-Q-ST-70-02C. Several outgassing parameters are measured that are widely used for the selection of materials in space engineering:
TML (Total Mass Loss), RML (Recovered Mass Loss), and CVCM (Collected Volatile Condensable Material), and WVR (Water Vapor Recovered). The ESA standard establishes the following requirements for the selection of materials for general use in space: RML < 1.00 % and CVCM < 0.10 %. NASA standards often require: TML < 1.00 % and CVCM < 0.10 %.

The micro-VCM facility has been accredited by the German accreditation body DAkkS for applied testing procedures in accordance with DIN EN ISO/IEC 17025:2018.

dlr.de/irs/en/vcm

Technical Data

System:

- Volume: 30 l
- Vacuum: 10^{-6} – 10^{-7} mbar
- Outgassing temperature: 398 K (125 °C)
- Required sample quantity: approx. 10 g

Standard

- ECSS-Q-ST-70-02C (conform to ASTM E595): TML, RML, CVCM, WVR

Analysis of contaminants:

- IR transmission measurement

Open M-VCM Test Facility with
Heatable Sample Station

UHV-Facility

The Ultrahigh vacuum facility researches the outgassing of materials or components that could be used in space or in vacuum facilities. It complements the Micro-VCM-Facility, which is only able to conduct irreversible tests on individual materials. Examples of components that have been tested are electrical motors, circuit boards, heaters and camera lenses. In addition, it is also possible to examine the success of cleaning procedures by testing materials or components in the UHV facility before and after the cleaning steps.

Tests carried out in the UHV facility are based on the comparison of measured outgassing rates in the test chamber before and after the test object has been introduced. Depending on the shape of the test object, the rate of outgassing can be determined either for a specific area, measured in mbar·l/s·m², or for all outgassing, measured in mbar·l/s. The measurements are usually taken over a period of 1-2 weeks in order to obtain additional information about the development of outgassing over time. Measurements are carried out with a mass spectrometer in the range of 1-512 u. This provides valuable information about possible causes for the rate of measured outgassing (e.g. the volume of trapped air, residue from cleaning agents, or outgassing from used materials).

dlr.de/irs/en/uhv

Purpose

Outgassing of material, mechanical parts and EEE comparts

Technical Data

• Volume of the test chamber:	12 l
• Volume of the lock chamber:	7 l
• Vacuum (empty test chamber):	approx. $5x10^{-10}$ mbar
• Sample temperature:	RT
• Outgassing rates measured by pressure rise method	
• Mass spectrometer:	1 – 512 amu
• The facility can be heated to approximately 500 K (230 °C)	

Outgasing Investigations of Materials at the UHV-Facility

Facility for Determination of Thermo-Optical Properties

“Thermo-optical properties“ means two optical properties that mainly influence the thermal behaviour of a surfaces.
These two properties are the “solar absorptance” (α) and the “infrared emittance” (ε).
The facility for the determination of thermo-optical properties allows to measure α_s (spectral solar absorptance) and ε_h (spectral hemispherical emittance) in accordance to the ESA standard ECSS-Q-ST-70-09C “Measurements of thermo-optical properties of thermal control materials“. The measurements are based on the detection of the hemispherical reflectance by using a spectrometer with suitable integrating spheres.

dlr.de/irs/en/thermooptisch

Technical Data

Spectrometer:	Bruker Vertex 80v
Vacuum:	approx. 2 mbar

Spectral range:

• α_s-measurement:	250 – 2500 nm
• ε_h-measurement:	3 – 25 µm

Integrating spheres:

• α_s-measurement:	white-diffuse
• ε_h-measurement:	gold-diffuse

Measured parameters:

- α_s, ε_h

Sample size:

- plain, approx. 4cm x 4cm

Spectrometer for the determination of thermo-optical properties

Concurrent Engineering Facility

The Concurrent Engineering Facility (CEF) is the systems analysis laboratory of DLR. It provides the necessary environment and tools to conduct Concurrent Engineering (CE) studies. CE is a process focused on optimizing engineering design cycles. This process complements and partially replaces the traditional sequential design-flow by integrating multidisciplinary teams that work collectively and in parallel, at the same site, with the objective of performing the design in the most efficient and consistent way as possible, right from the beginning.

The CEF facilitates simultaneous access to a common set of data, as well as direct communication among the different scientific and engineering domains during the design process, through the use of modern tools and communication technologies.

The CEF is divided into 3 design rooms with 15 work stations and built-in media capabilities. One of these chambers is the “Main Design Room“, where studies are conducted and which allows for up to 12 technical domains.

dlr.de/irs/en/cef

Technical Data

- Three design rooms
- Capacity for up to 30 people working simultaneously
- 15 workstations with specific distributed software, as well as common tools (STK, CATIA, Matlab)
- Videoconferencing system with integrated HD cameras and media
- Media Management System
- One four-point LED interactive touch screen, and 2 large LED display screens
- Secure network
- Two common servers (Windows; Linux)
- Public WLAN access

The Concurrent Engineering Facility (CEF) at DLR Bremen

HiLT – Hardware-in-the-Loop Technology Laboratory

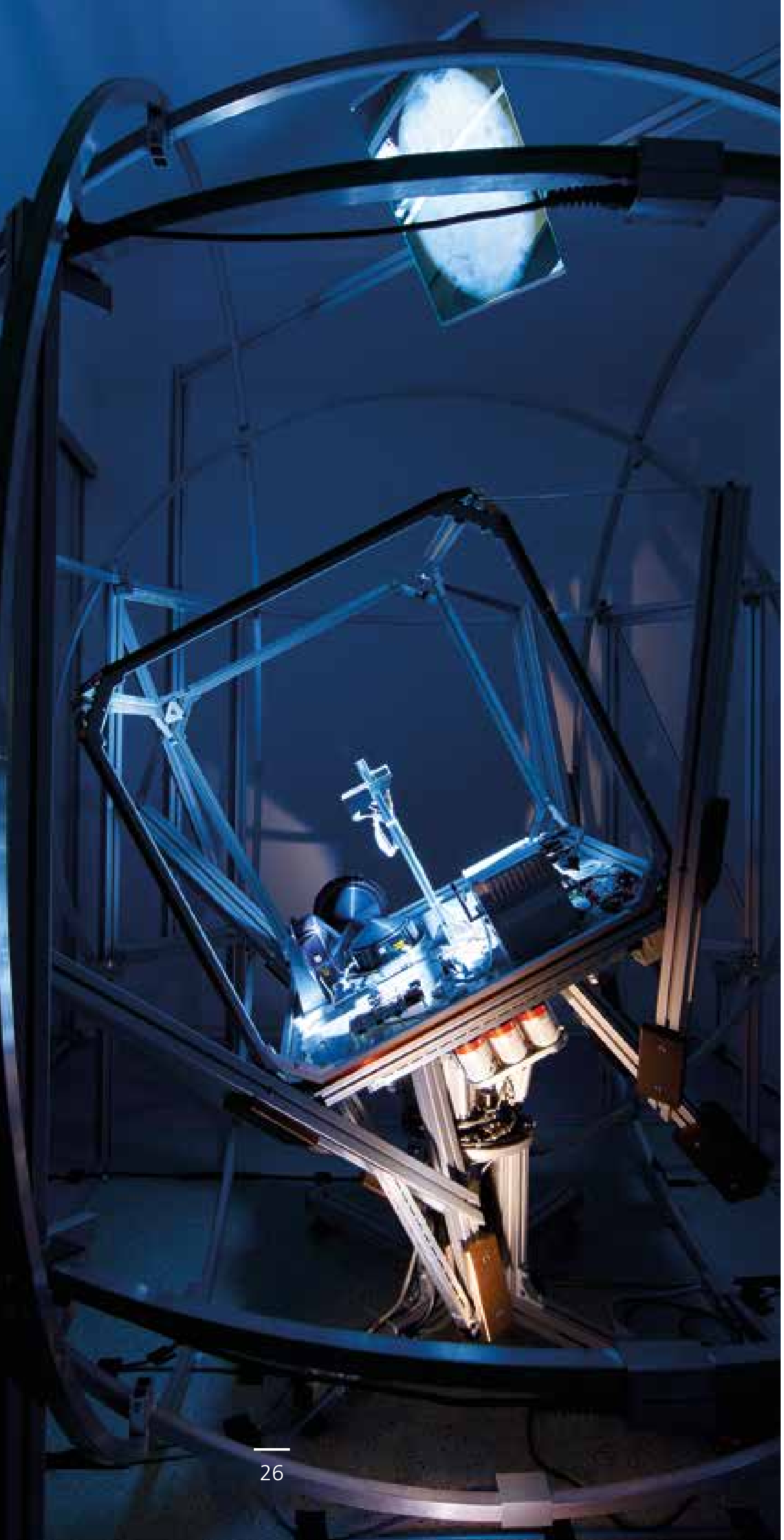
The Hardware-in-the-Loop Technology Laboratory (“HiLT Lab”) serves as a development laboratory for Guidance, Navigation and Control (GNC) systems for space applications. As part of the Department of Guidance, Navigation and Control Systems at the DLR Institute of Space Systems, it offers a broad spectrum of infrastructure for all aspects of the development of GNC systems, starting with the initial design of systems and components up to the preparation for their integration into flight systems. The lab is focused on the development, simulation, test, and verification of the embedded systems required for GNC applications. To this end, it is necessary to combine processors, sensors, actuators, and supporting electronic components into one real-time system. Using different simulation platforms and sensor simulators, the lab offers the possibility of integrating real GNC hardware into so-called Hardware-in-the-Loop simulations (HiL simulations), which can be used to test individual hardware components and their interactions with software modules.

dlr.de/irs/en/hilt

Technical Data

- dSPACE Real-Time Simulation Platform
- GPS/SBAS Simulator
- High Performance Computing Cluster
- Optical Real Sky Simulator (OSI)
- Climate Test Chamber for Temperature Range from 213 K to 453 K -60 °C to +180 °C
- RASTA Development Platform for LEON2-based Space Avionics
- TTEthernet Development Hardware
- Thermal Imaging Camera
- Stereo Microscope Station

Main Lab Workbenches



FACE – Facility for Attitude Control Experiments

One major aspect for verifying the attitude control systems of a satellite is to artificially create an environment which resembles real space environment as close as possible. This includes micro gravity, magnetic field, solar radiation, Earth albedo and stellar background.

The Facility for Attitude Control Experiments allows simulating such an environment to verify an attitude control system. The most challenging aspect here is to mimic the micro gravity environment. Therefore, a torque-free rotation of the satellite body around its center of mass is required. Such a rotation is created through a spherical air-bearing table. The satellite under test can have a mass up to 180kg and a volume of 0.6 x 0.6 x 0.6 m^3.

dlr.de/irs/en/face

Technical Data

- Maximum additional mass on the platform: 180 kg
- Maximum mounting envelope: 0.6 x 0.6 x 0.6 m^3
- Adjustable moment of inertia between 15 and 30 kgm^2
- Adjustable external magnetic field between: +/- 210 000 nT
- External Sun sensor stimulation available
- External artificial star pattern available
- Remaining disturbance torque after calibration: ~10^{-5} Nm
- Available attitude control hardware components:
  4x Reaction Wheels, 1x Control Momentum Gyroscope,
  6x Magnetic Coils, 2x Star Cameras, 3x Angular Rate Sensors,
  2x Magnetometers, 1x Inertial Measurement Unit, 1x On-Board Computer (QNX operating system)

Air bearing Table Simulating the Attitude Motion of a Satellite in Space

STARS – Sensor Testing and Assessment on a Rotation Simulator

In aerospace, seafaring, autonomous mobility, and navigation devices for both smartphones and cars, sensors are used to determine the position and attitude. The STARS Laboratory offers a test bench for the characterization of accelerometers, gyroscopes, inertial measurement units, Sun sensors, star trackers, and angle sensors. These tests enable the creation of highly precise sensor models which reflect the sensor characteristics. This sensor information is crucial for the development, optimization, validation and verification of the aforementioned navigation systems.

dlr.de/irs/en/stars

Technical Data

Rotation Table (ACUTRONIC AC3347)

- Continuing rotation around three axes with max. 1000°/s
- Max. rotational speed acceleration till 30000°/s²
- Position resolution 0.00001°
- Temperature stabilization through climate chamber from 323 K to 353 K (50 °C to 80 °C)

GPS Simulator Spirent GSS 7700

- 4 – 32 channels on two outputs for different RF signals L1/L2/L5
- Real-time remote control and simulated flight path for hardware-in-the-loop testing
- Interference of up to 16 channels on L1 band

Sun simulator neonsee HCSS-21-H

- Usable illumination field: 200 × 200 mm
- Adjustable collimation angle from 0.368° (Venus) to 0.051° (Jupiter)
- Adjustable irradiance from 1780 W/m² to 2.5 W/m² (to 162 W/m² with AM0 spectrum)

STARS Testbed with Sun Simulator and Rotation Table

TEAMS – Test Environment for Applications of Multiple Spacecraft

The Test Environment for Applications of Multiple Spacecraft (TEAMS) test facility is a laboratory for simulating the forces and torque-free dynamics of several satellites on ground. It consists of two highly smooth and even 4 m x 2.5 m granite tables on which several air cushion vehicles can glide. To simulate precise formation flying, as in astronomical missions, two vehicles can be used to simulate five degrees of freedom (TEAMS_5D).

To simulate satellite swarms, smaller vehicles with three degrees of freedom can be used (TEAMS_3D). These vehicles do not have a rotating upper platform and can only rotate around one axis. They are used to test formation acquisition, formation reorientation and path planning algorithms.

The main task of the TEAMS facility is to test satellite formation control algorithms on ground. However, sensors for relative attitude and position as well as spacecraft behaviour during berthing and docking manoeuvres (contact dynamics) can also be investigated using this facility.

dlr.de/irs/en/teams

Technical Data

- 2 granite tables 2.5m x 4m
- 2 vehicles with 5 degrees of freedom:
  Rotatable upper platform
  16 cold gas thrusters
  3 reactions wheels
  IMU
- 4 vehicles with 3 degrees of freedom:
  6 cold gas thrusters
- Onboard computer with QNX RTOS
- Infrared tracking system

Test of Control Systems for Spacecraft Docking in the TEAMS Laboratory

TRON – Testbed for Robotic Optical Navigation

The Testbed for Robotic Optical Navigation (TRON) is a Hardware-in-the-Loop Test (HiLT) facility, with the purpose to support the development of optical navigation technology. TRON provides an environment which allows qualifying breadboards to TRL 4, and qualifying flight models to TRL 6-7. Typical sensor hardware which can be tested in TRON are active and passive optical sensors like lidars and cameras.

The major components of the lab are a robot on a rail for dynamic positioning of the sensor under testing, a dynamic lighting system for illumination of the targets, laser metrology equipment for high precision ground truth and a dSPACE real-time system for test observation and control, and synchronization of ground truth and sensor data. The laboratory can be customized with user defined hardware such as models of a Lunar or Martian surface. Thanks to this flexibility as well as to its extensive dimensions TRON is well suited for creating scenes representative for the ones encountered by optical sensors during exploration missions.

dlr.de/irs/en/tron

Technical Data

Tools for ground truth determination:
- Laser Tracker with micrometer accuracy
- various targets available for tailored reference data work flow
- 3D and 6D measurements possible

Dynamics
- several targets available for customized laser tracker based 3D and 6D measurements
- max payload 40 kg (with 16 kg at robot hand)
- max velocity 1.5 m/s
- positioning precision repeatability of 0.2 mm

3D terrain models for simulating
- high altitude lunar orbits 4 x 2 m^2 1:125000
- medium altitude orbits 10 x 2 m^2 1:10000
- landing phase 4 x 2 m^2

Lighting
- motorized 2-axis HMI lamp on a 3-axis gantry
- color temperature: 6000 K with 575 W

Simulation Section of TRON

Landing & Mobility Test Facility

At the Landing & Mobility Test Facility (LAMA) the landing dynamics of planetary landers and rovers are investigated by the realistic simulation of weight, dynamic and surface properties. Important issues to be addressed include stability when landing on an inclined surface with lateral speed, safety when landing on rough terrain, as well as vehicle-surface-interaction on granular surfaces.

LAMA is a modular testbed with a size of 4 x 10 m^2 containing the planetary surface. A section of 4 x 4 m^2 can be tilted up to 30° to simulate the terrain slope. Another key element of the facility is a mobile industrial robot system (KR500) with individual suspensions, designed to ensure accurate control of the test object.

dlr.de/irs/en/lama

Technical Data

- Test object mass: up to 500 kg
- Size: 3 m foot print diameter
- Inclination: up to 30°
- g-level compensation: up to 10^{-3} m/s^2
- Data recording: Video- and sensor signals up to 9.6 kHz

LAMA with Lander Engineering Model

Cryo-Laboratory

The mission of the Cryo-Lab is to facilitate conditions that enable scientific research and technical development of propellant management technologies of launcher systems. The focus is on tank systems, tank components and functional propulsion issues.

The Cryo-Lab provides the opportunity to perform experiments and tests with the cryogenic propellants of launcher systems. It is especially designed for handling of liquid hydrogen, liquid oxygen and liquid methane. Additional testing is feasible with storable liquids and with liquid nitrogen. The Cryo-Lab is designed to provide a maximum of flexibility and offer a wide range of possibilities for experimentation. Research is carried out in the areas of basic and material science as well as functional and qualification tests. The Cryo-Lab has special test facilities with unique selling point.

dlr.de/irs/en/kryo

Technical Data

Test Facilities

- Explosion protected laboratory (intended)
- Hexapod (6 DOF)
- ATEX-Sloshing Table (1 DOF)
- Tilt table
- Rotational Platform
- Vacuum Chamber
- Cryostats
- Cold Head

Cryogenic Liquids

- Liquid Hydrogen
- Liquid Oxygen
- Liquid Methan
- LNG
- Liquid Nitrogen

Measurement Systems

- High Speed Camera
- Pressure Sensors
- Temperature Sensors
- Gasanalyse
- Force Sensors
- Acceleration Sensors
- Volume Flow Sensors
- Mass Flow Sensors
- Interrogator for Fibre Optic
- Fibre Optic Sensors (FBG)
- PIV Flow Measurement System

Cryogenic Tank Demonstrator provided by Airbus Safran Launchers on Hexapod

Electronic Laboratory

The electronics development laboratory hosts several ultramodern measuring workstations. With regard to metrological capabilities, the laboratory's key competencies lie within the field of telecommunications and high-frequency technology. To this end, high-quality measuring instruments are available, including a network analyser of up to 20 GHz, EMC test receivers, performance measuring instruments and spectrum analysers. A variety of EMC measuring technologies and fast signal analysis are also available.

Many in-house developments and prototypes are developed and constructed in the electronics laboratory, such as microstrip antennas, transmitters and receivers. The electronics laboratory is involved in all projects undertaken on site. The electronics laboratory is also home to the radio-based ground station, which enables radio contact to be established with satellites, the reception of AIS and ADS-B signals and general communication. The amateur radio, Clubstation, whose international radio call sign is DK0DLR, is used for practical training, and is affiliated with the ground station.

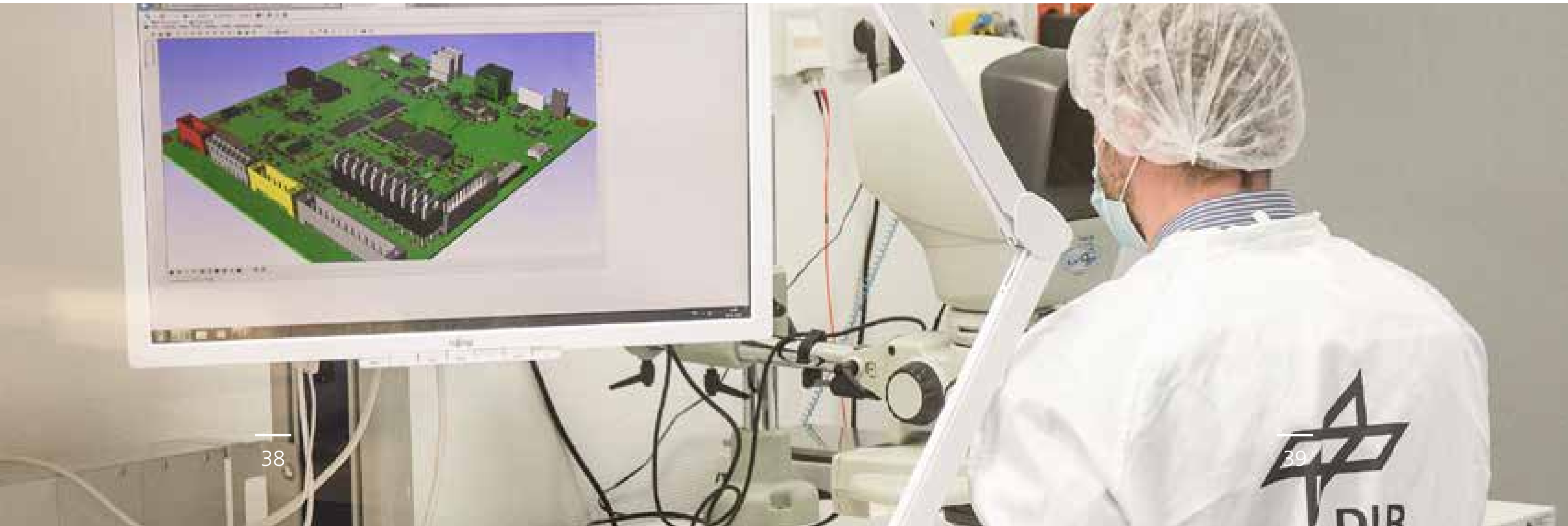
Areas of research include the development of antennas and optimization for use in space. Receivers are also improved and modified according to their current application, an example of which is SDR technology.

dlr.de/irs/en/elab

Technical Data

- EMC Pre-Compliance, EMC Faraday tent
- Signal absorption 1 MHz-20 GHz > 50 dB
- EMI Test Receiver up to 26.5 GHz
- Network analysis up to 20 GHz
- RF power measurement and signal generation
- PCB design and manufacturing
- High bandwidth signal analysis
- Satellite ground station for nano satellites
- Remote controlled satellite ground station
- 3D EM simulation with various state-of-the-art software tools
- Rapid Prototyping (PCB/3D)

Electronic PCB check



EMC – Laboratory for Electromagnetic Compatibility

Electromagnetic compatibility (EMC) of electronic or electrical systems and components is the ability to function satisfactorily in a given electromagnetic environment without emission of intolerable electromagnetic disturbances. To verify the compatibility of systems and components for space applications - the EMC testing laboratory can simulate various electromagnetic conditions for susceptibility tests, and measure the radiated and conducted electromagnetic disturbances caused by the equipment under test (EUT) by emission tests.

The tests are carried out according to the standards for space engineering ECSS-E-ST-20-07C and MIL-STD-461F. These tests are essential for safe operation during the mission.

dlr.de/irs/en/emv

Technical Data

- Conducted emission on power leads, 30 Hz to 100 MHz
- Measurement of the inrush-current
- Radiated emission of electrical field, 10 kHz to 18 GHz
- Conducted susceptibility, 30 Hz to 100 MHz
- Conducted susceptibility to transient disturbance
- Radiated susceptibility of electrical fields, 30 MHz to 80 MHz - max. 10 V/m, 80 MHz to 6 GHz - max. 20 V/m

The Absorber Chamber according to MIL Standard 461

Integration Laboratory

The integration laboratory enables projects for flight missions. Depending on the on-board instrument's scientific main goal and the destination of the spacecraft, flight missions are assembled under various degrees of cleanliness degree. The main goal of the Integration Hall is to guarantee an environment for particle-reduced integration, which can be different at various workstations depending on the project. Work with instruments which will search for the existence of life on planets requires a special protection from contamination by microorganisms.

Successful missions have already been completed in Bremen such as MASCOT, AISat, Eu:CROPIS and InSight.

dlr.de/irs/en/integration

Technical Data

- 250 m^2 integration area
- Clean room of class ISO 8
- ISO 5 under Laminar Flow-Bench
- Planetary Protection Integration
- Two control rooms
- Five particle counters
- CAST (Core Avionics System Test Bed) Two robots for solar module manufacturing & integration support

Overview of the Integration Laboratory

Planetary Infrastructures Laboratory

The Planetary Infrastructures Laboratory offers excellent capabilities to develop new Bio-regenerative Life Support Systems (BLSS) and In-Situ Resource Utilization (ISRU) technologies. The laboratory is compartmentalized in different rooms, each providing equipment and work space to develop, build and conduct several scientific experiments in parallel.

A unique aspect of this laboratory is the controlled environment area, which provides more than 30 m² for experiments regarding plant cultivation and technology evaluation for applications in BLSS for future space exploration missions.

dlr.de/irs/en/eden

Technical Data

- 150 m² laboratory area and 35 m² workshop area
- Controlled environment area (32 m²) for plant cultivation experiments and BLSS hardware evaluation
- State-of-the-art controlled environment agriculture subsystems (nutrient delivery, atmosphere control, LED illumination)
- ISRU experiment area including a laminar-flow bench, a regolith beneficiation test stand and various regolith simulants
- Several analytical equipment for BLSS and ISRU (e.g. drying oven, pH probes, photo-spectrometer, particle analyzer, XRF spectroscopy)

Main closed-loop test greenhouse within the Planetary Infrastructures Laboratory

CAT – Core Avionics Testbed Laboratory

The Core Avionics Testbed (CAT) Laboratory provides the environment for functional verification of space systems from system down to equipment level. The focus is on testing core avionics equipment - which includes the electrical power subsystem, onboard data handling subsystem and communication subsystem - but is not limited to. The equipment can be verified stand-alone, or in an incrementally completed system. Components that are still not available can be emulated by the test environment. This allows to verify equipment in a nearly complete functional-relevant environment already in early development phases, which helps to avoid expensive trouble shooting in late project phases.

In addition to offering testing services, the laboratory is also used for research on the testing process itself. Fully digitalization and direct traceability to the model-based design process are declared goals. This enables a high degree of automation on test specification, configuration, execution and monitoring, analysis and documentation.

dlr.de/irs/en/cat

Technical Data

- Power system special checkout equipment consisting of a battery simulator, solar array simulator, electronic loads and a modular power controller breadboard for emulating power controller functionality.
- Radio Frequency (RF) special checkout equipment based on a Safran Cortex CRT-Q to emulate the RF path including losses, noise and doppler effects.
- dSPACE real-time simulation platform for sensor and actuator simulation
- Equipment for the characterisation of space branch typical data interfaces, such as SpaceWire link analyser and physical layer tester
- Hardware is handled in an ESD protected area, qualified for susceptibilities of up to 100V (HBM), 200V (CDM) and 35V (isolated conductors)

Testing Activities in the Core Avionic Testbed Laboratory

About DLR

DLR is the Federal Republic of Germany's research centre for aeronautics and space. We conduct research and development activities in the fields of aeronautics, space, energy, transport, security and digitalisation. The German Space Agency at DLR plans and implements the national space programme on behalf of the federal government. Two DLR project management agencies oversee funding programmes and support knowledge transfer.

Climate, mobility and technology are changing globally. DLR uses the expertise of its 55 research institutes and facilities to develop solutions to these challenges. Our 10,000 employees share a mission – to explore Earth and space and develop technologies for a sustainable future. In doing so, DLR contributes to strengthening Germany's position as a prime location for research and industry.

Lab Brochure Bremen_07/22

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