Survey of Facilities

Space Division

TN-TR-1000, Issue 23, August 26, 2022

Main Building Complex of the Space Test Centre incl. Competence Centre Optics

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Magnetic Test Facilities 46

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Mass Property Measurements **52**

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Calibration Facilities for Dynamic Motion Measuring Equipment **56**

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Calibration Facilities for Electric and Thermo-Electric Quantities **56**

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IABG operates the national space test centres at Ottobrunn near Munich, Germany. It is IABG's daily business to perform all kinds of tests as described below. All test facilities at IABG's Space Division are combined under one roof and easily accessible, as can be seen from the ground plan (see Fig. 1). During many demanding tests on spacecraft and other specimen, IABG has proven to be most efficient and reliable. The Space Division includes facilities for:

1. Space Simulation / Thermal Vacuum

Four thermal vacuum chambers with inner diameters of 6.2 m, 3.6 m, 2.5 m, and 2.1 m are available for thermal vacuum tests. The development and operation of a spacecraft require design and functional performances of a thermal control subsystem to ensure an adequate thermal environment for the various components on board.

The design and the functional performance of the thermal subsystem and the complete spacecraft system are studied in thermal test facilities (also called heat balance, space simulation or thermal vacuum facilities).

Under simulated thermal space conditions, verification of the thermal model calculation and qualification as well as acceptance of the functional performance of the thermal control subsystem and the spacecraft system have to be achieved. The essential space conditions which are simulated in large thermal testing facilities are vacuum conditions, radiative heat sink, solar radiative input and thermal loads. A comprehensive data handling system is available for collection, computation and monitoring of measured test data.

2. Vibration and Shock

The vibration laboratory is equipped with an electrodynamic multi-shaker system (force vector 500 kN) and a number of single shakers of different sizes. Some facilities are equipped with climatic chambers for combined vibration and thermal loading.

The facilities are computer controlled and allow the simulation of sine, random, sine-on-random and transient excitation. A digital data acquisition and processing system provides up to 250 channels for acceleration and 100 channels for strain and force measurements per facility in standard configuration. However, due to the communality of the data acquisition with the modal and the acoustic facility, the maximum channel count for a test project is not limited to these numbers and can even be extended up to 1,000 channels.

Unique classical shock test machines as well as a dedicated tool for the simulation of pyroshock events round up the comprehensive mechanical services.

3. Modal Testing

Modal testing is required to validate dynamic mathematical models or to investigate the dynamic (operational) behaviour of structures in detail.

A versatile mobile modal test system is available which incorporates the latest hardware and software technologies and which may be used for both small and large modal tests. The maximum channel count amounts up to 1,000 and may be incremented in steps of 126 channels. The complete system is mobile and may be used table top, smaller portions of it even in vehicles. The modal test system is complemented by various excitation means including modal exciters rated 10 N up to

7 kN as well as a scanning laser vibrometer for contactless vibration measurements.

Powerful software tools are used for test control and evaluation of the measured signals. The available comprehensive modal analysis tools enable customised solutions for even unconventional testing tasks in the sphere of aerospace and general engineering.

4. Acoustics

Acoustic noise tests are performed in the reverberation chamber offering a volume of 1,378 m³ to qualify test objects against the acoustic environments up to 156 dB OASPL as encountered during the launch of a spacecraft. For re-entry and engine noise acoustic environments, equipment can be subjected to fluctuating pressure fields in a special Progressive Wave Tube up to 170 dB OASPL. Up to 256 response acceleration and 64 strain measurements can be taken in a standard configuration and up to 24 microphones for the control and measurement of the noise field. However, due to the communality of the data acquisition with the modal and the acoustic facility, the maximum channel count for a test project is not limited to these numbers. The control of the acoustic noise field can be performed either manually or automatically.

5. EMC

The EMC test facility consists of a large and two medium anechoic chambers, each with an anteroom for measurement equipment and customer EGSE. Frequency domain emission tests can be performed with computer controlled EMI-receivers up to 40 GHz and time domain measurements with digital and analogue oscilloscopes up to 5 GS/s. Susceptibility test equipment allows to generate fields with more than 4,000 V/m and up to 40 GHz. Lightning; ESD, Power Simulation and other time domain effects can be carried out.

With the available test equipment and a unique infrastructure (power interfaces, clean room), complex test objects can be qualified both according to most EMC standard procedures and according to special customer requirements.

6. Magnetics

IABG's Space Division has one of the most sophisticated magnetic test facilities in the world which is unique in Europe. Thanks to the facility, IABG covers a domain not covered by standard EMC test facilities, i.e. the frequency range below 25 kHz down to DC. This enables customers to test whether magnetometers function properly in conjunction with other scientific instruments in the payload and with the spacecraft itself during different magnetic conditions that are encountered during integration, testing, launch, and in orbit.

7. Mass Property Measurements

For satellites, space probes, launcher parts, payloads, or for any kind of general engineering systems a complete set of facilities is available for the accurate determination of the mass properties.

These measurements comprise the determination of mass (weight), centre of gravity (CoG), moment of inertia (MoI) and product of inertia (PoI). Furthermore static and dynamic balancing can be performed.

Specimens can be handled from system level size of up to 3.5 tons down to subsystem level.

Ground Plan of the Space Test Centre

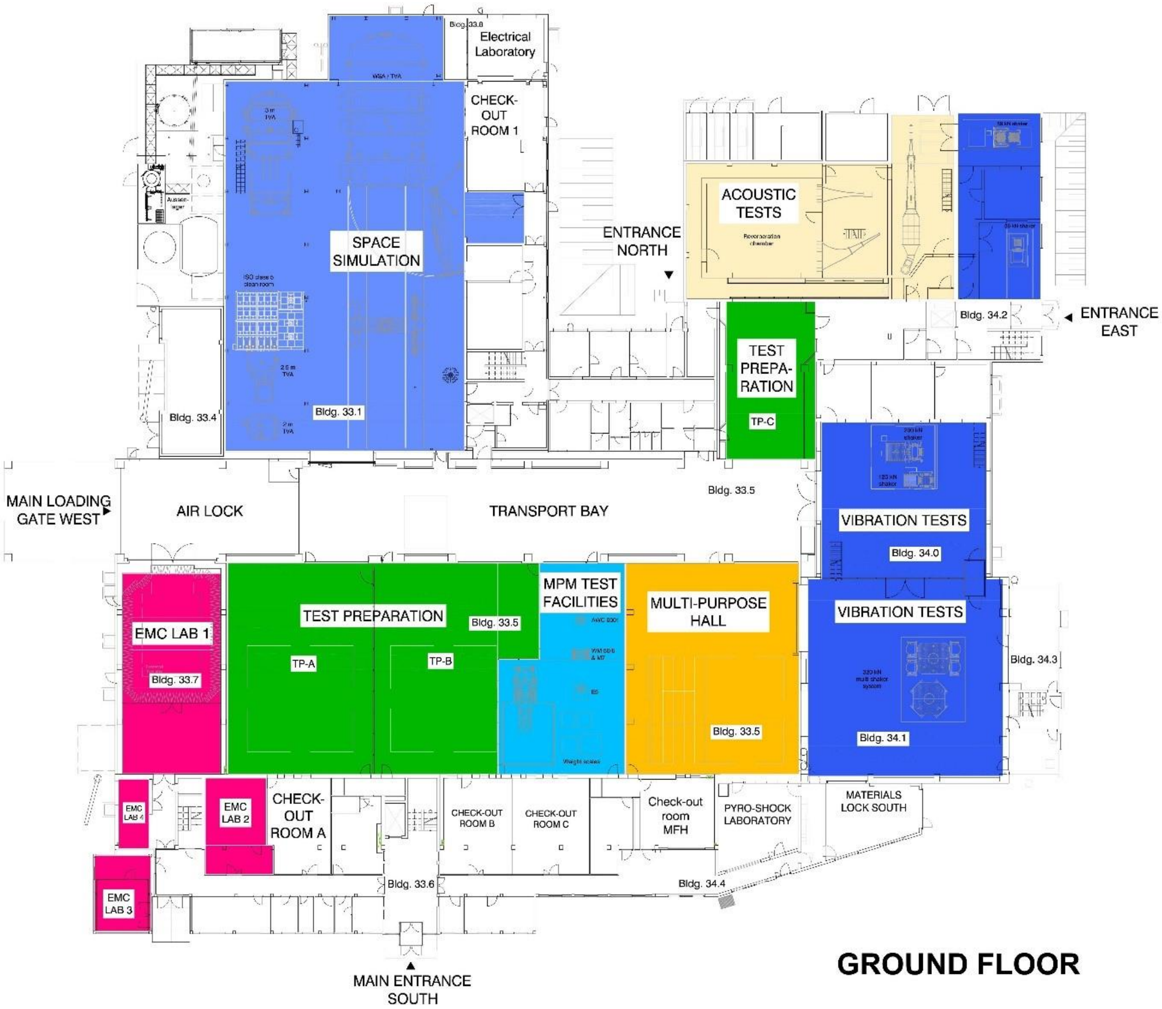
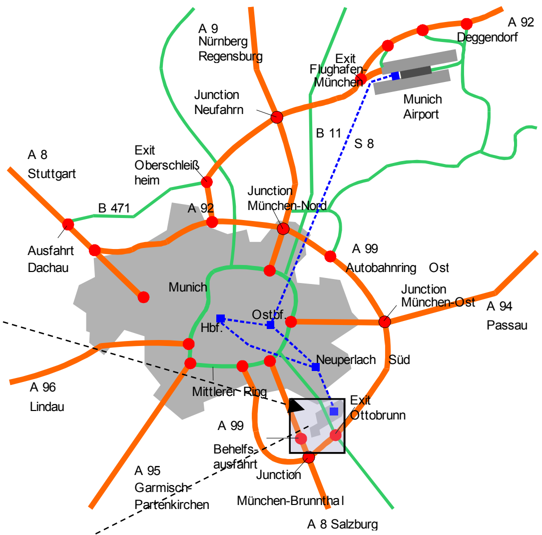


Fig. 1: Ground Plan of the Space Test Centre

Location of the Space Test Centre

In connection with preparation halls and checkout rooms, with environmental simulation facilities (climatic chambers, etc.), with static and dynamic test facilities even for large structures, with a material test laboratory at IABG, and with a compact antenna / payload test range in the immediate vicinity (operated by Airbus Defence and Space GmbH), this centre offers an exceptional combination of test facilities for space applications.



How to reach IABG in Ottobrunn:

Access by public transport:

- From **Munich Airport** by rapid transit train line S8 till München-Ostbahnhof (cont. see from München-Ostbahnhof).
- From **Munich Central Station (Hauptbahnhof)** by rapid transit train lines **S1, S2, S3, S4, S6, S7** and **S8** till München-Ostbahnhof (cont. see from München-Ostbahnhof) or by rapid transit train line S7 till Neuperlach Süd (cont. see from Neuperlach-Süd) or till Ottobrunn (cont. see from Ottobrunn) or by subway line U5 till München-Ostbahnhof (cont. see from München-Ostbahnhof) or till Neuperlach-Süd (cont. see from Neuperlach-Süd).
- From **München-Ostbahnhof** by bus line **x200** till stop Taufkirchen *Willy-Messerschmitt-Straße* or till stop Taufkirchen *Lilienthalstraße* or by rapid transit train line **S7** till Neuperlach-Süd (cont. see from Neuperlach-Süd) or till Ottobrunn (cont. see from Ottobrunn) or by subway line **U5** till Neuperlach-Süd (cont. see from Neuperlach-Süd) rapid transit train or subway.
- From **Neuperlach-Süd** by bus line **210** till stop Ottobrunn *Einsteinstraße* or by bus line **222** till stop Taufkirchen *Lilienthalstraße*.
- From **Ottobrunn station** by bus line **241** till stop Taufkirchen *Lilienthalstraße* or by bus line **214** till stop Ottobrunn *Einsteinstraße*
- From bus stops Taufkirchen *Willy-Messerschmitt-Straße,* Taufkirchen *Lilienthalstraße* and Ottobrunn *Einsteinstraße* you will reach IABG within a few minutes (see also site plan).

Please find out details concerning departure times of Munich's public transport

- U5 / Bus 210: every 10 minutes • S7 / Bus 241: every 20 minutes
- Bus x200 / 222: at rush hours every 5 or 30 minutes
- Bus 214: every 60 minutes • at rush hours every 20 or 40 minutes

All timetables of Munich public transport facilities are available under **www.mvv-muenchen.de/en/homepage/index.html**

Access by road:

 From direction **Munich Airport (A 92)** at junction Neufahrn onto A 9 direction Salzburg and at junction München-Nord onto A 99, direction Salzburg till exit Ottobrunn (cont. see from Ottobrunn).
 From direction **München-Zentrum (A 8)** direction Salzburg till exit Taufkirchen-Ost (cont. see from Taufkirchen-Ost).
 From direction **Nürnberg (A 9) and Regensburg (A 93 / A 9)** at junction München-Nord onto A 99 direction Salzburg till exit Ottobrunn (cont. see from Ottobrunn).
 From direction **Stuttgart (A 8)** at junction München-Eschenried onto A 99 till exit Ottobrunn (cont. see from Ottobrunn).
 From direction **Rosenheim / Salzburg (A 8)** till exit Taufkirchen-Ost (cont. see from Taufkirchen-Ost).
 From direction **Lindau (A 96) / Garmisch (A 95)** via "mittlerer Ring Süd" direction Salzburg onto A 995. At junction München-Süd follow the signposting Nürnberg (A 99) M-Ramersdorf. Via exit M-Ramersdorf onto A 8 exit Taufkirchen-Ost (continuing from Taufkirchen-Ost). Alternatively from direction Lindau (A 96) at junction München-Südwest onto A 99 West, A 99 Ost till exit Ottobrunn (cont. see from Ottobrunn).
 From direction **Passau (A 94)** at junction München-Ost onto A 99 direction Salzburg till exit Ottobrunn (cont. see from Ottobrunn).
 From exit **Taufkirchen-Ost** please follow the signposting "Gewerbegebiet Taufkirchen-Ost II" (B 471) and turn off at signposting "Taufkirchen-Ost II / Airbus Group" (2nd road to the left, Willy-Messerschmitt-Str.). So you drive directly towards IABG.
 From exit **Ottobrunn** please continue direction Ottobrunn / München till the next intersection (traffi c light). Here turn to the left direction Unterhaching / Taufkirchen onto B 471. Please leave the B 471 at the signposting Taufkirchen I / IABG on the right hand side.

INFORMATION FOR USERS OF NAVIGATION SYSTEMS
Please enter the following destination:
Lilienthalstr. 12 • 85521 Taufkirchen bei München

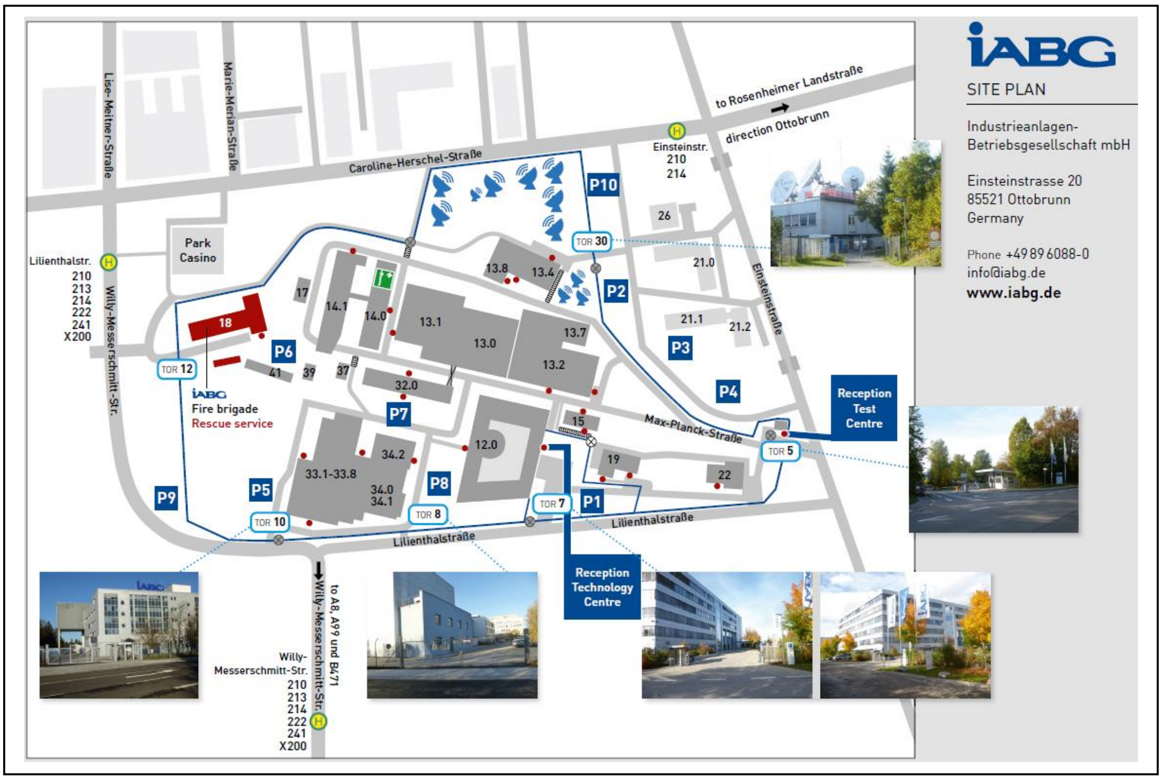


Fig. 3: Site Plan of IABG

Space Division

Test Preparation and Checkout Rooms

Test Preparation Hall with Tandem-X, CryoSat 2 and Ariane 5+ ESC-A upper stage

1. Summary

Adjacent to each space test facility, there are preparation areas for the specific preparations of the test objects. In addition, general preparation areas are available for the customer, with nearby checkout rooms which are provided with cable links to the individual test facilities. Also available are customers offices and storage areas.

2. Description and Data

Fig. 4 shows the location of the test preparation halls A, B and C, the Multi-Purpose Hall, the checkout rooms A and B, the transport bay and the air lock in buildings 33.5 and 33.6. Their main characteristics are described in Tab. 1 - 4. Each test preparation area includes a 10 m x 10 m floor section on separate seismic foundations.

The maximum floor loading allowable throughout the test preparation hall and the transport bay areas is 20 kN/m² or 250 kN block load on an area of 2.5 m x 2.5 m. The maximum floor loading allowable in the checkout rooms is 20 kN/m² or 5 kN point load.

Electrical power is supplied in two ways: standard power of 50 kW per area or room and an uninterruptible emergency power totalling 100 kVA. Also available are signal lines to the test facilities, special earth, telephone lines, speaker system, etc.

All halls and rooms are air-conditioned and the halls maintain a cleanliness standard corresponding to clean class ISO 8 according to ISO14644-1. The air conditioning systems are designed for temperatures of 22°C ± 3°C, and for a relative humidity of 55% ± 10%.

Tab. 1

	Test Preparation			Multi-Purpose Hall
	Area A	Area B	Area C	
Area (m²)	272	266	110	326
Height to Ceiling (m)	15.3	15.3	15.3	15.3
Max. Height to Crane Hook (m)	11.3	11.6	11.6	11.6
Door Size, Width x Height (m)	6 x 10	6 x 10	6.2 x 9.9	5.9 x 10.0 6.3 x 11.0
Max. Heat Dissipat. (kW)	30	35	35	45
Cranes: Max. Load (kg)	10,000	10,000	16,000	10,000
Speed see Tab. 3 and 4				

** both cranes run through entire transport bay and air lock*

Tab. 2

	Checkout Room A	Room B	Room C	MFH	Transport Bay / Air Lock
Area (m²)	52	59	64	45	420 / 150
Height to Ceiling (m)	3.5	3.5	3.5	3.5	12.3
Max. Height to Crane Hook (m)	—	—	—		9.8
Door Size, Width x Height (m)	1.4 x 2.2	1.4 x 2.2	0.9 x 2.2		7.7 x 12.3
Max. Heat Dissipat. (kW)	30	35	10		45 / 23
Cranes: Max. Load (kg)	—	—	—		20,000/10,000*
Speed see Tab. 3 and 4					

* both cranes run through entire transport bay and air lock

Tab. 3

Crane Speeds in Transport Bay and Air Lock (both cranes)

	Slow	Medium	Fast
Up/Down	0.12 m/min	2 m/min	6 m/min
North/South	0.4 m/min	5 m/min	20 m/min
East/West	0.8 m/min	10 m/min	40 m/min

Tab. 4

Crane Speeds in Test Preparation Areas A and B and Multi-Purpose Hall

	Slow	Medium	Fast
Up/Down	0.12 m/min	2 m/min	6 m/min
North/South	0.4 m/min	5 m/min	20 m/min
East/West	0.4 m/min	5 m/min	20 m/min

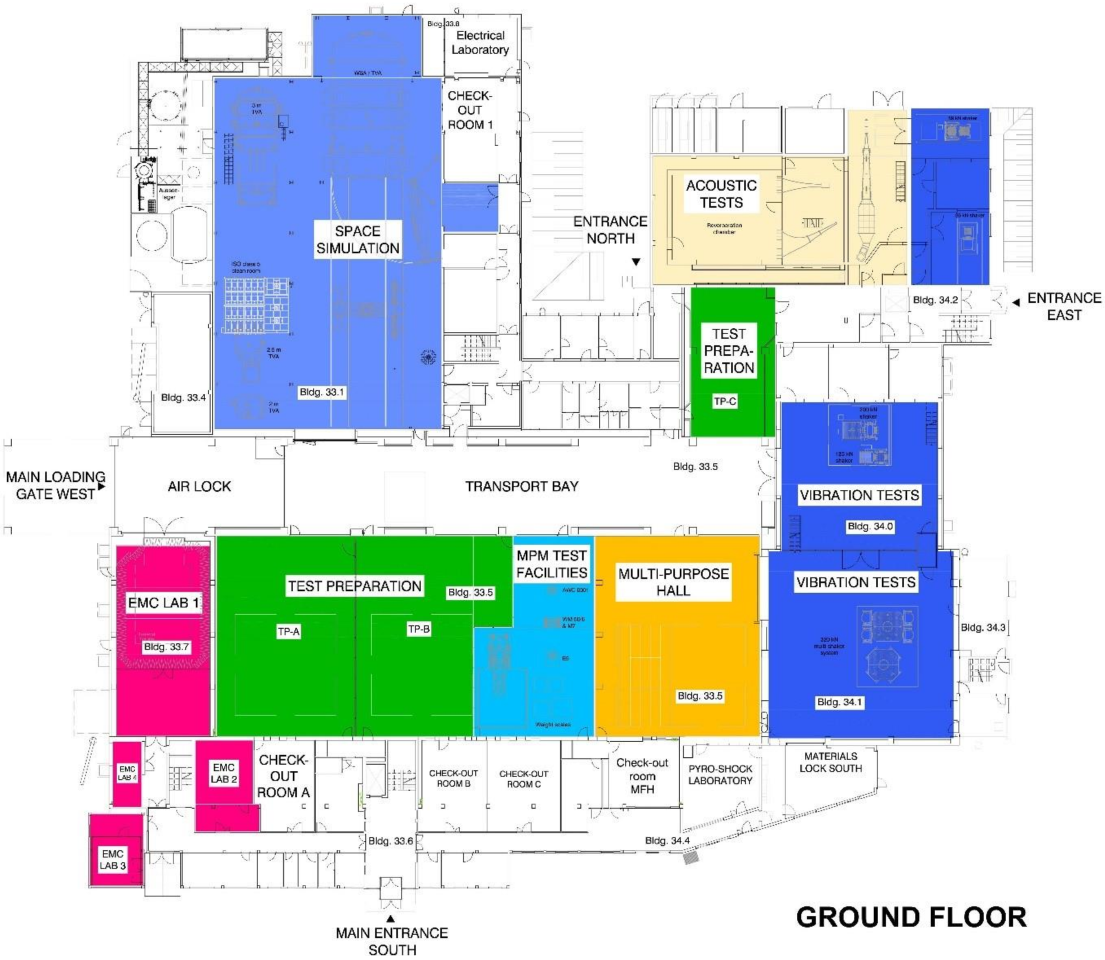
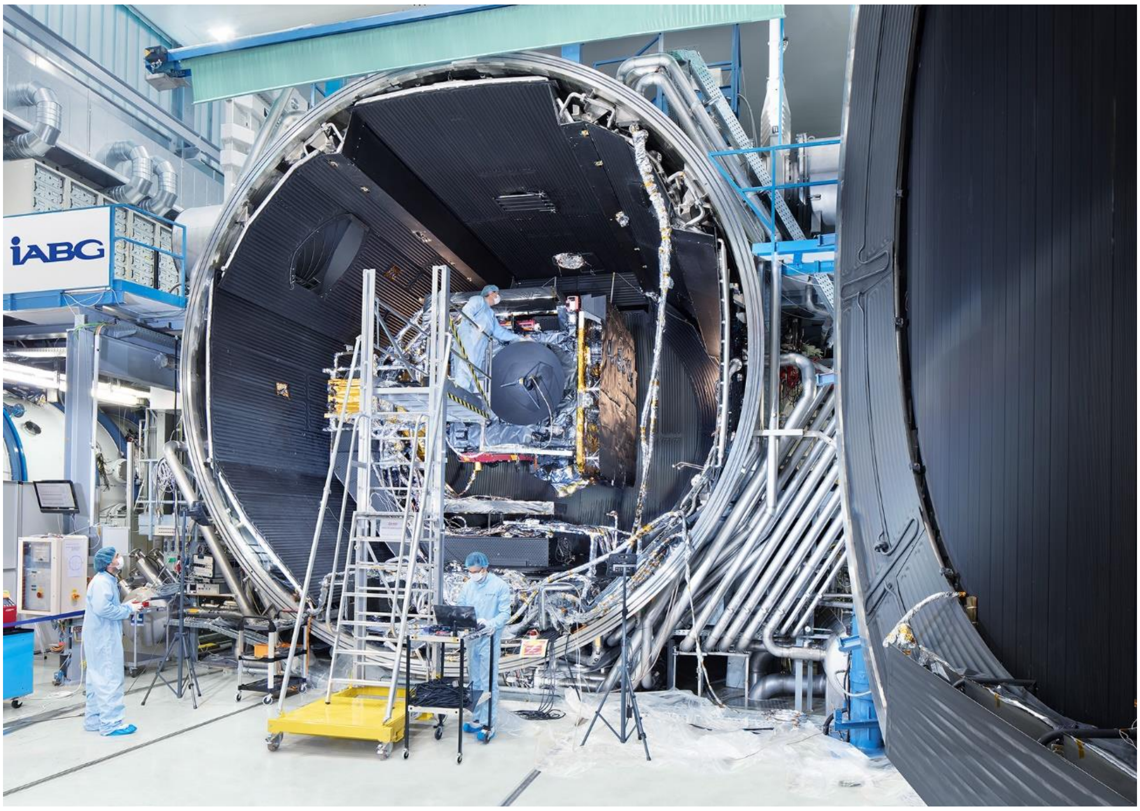


Fig. 4: Test Preparation Areas, Check-Out rooms and Clean locks, Multi-Purpose Hall and Air Lock in Buildings 33.5 and 33.6

Space Division

Space Simulation /
Thermal Vacuum Facilities



SOLAR ORBITER in the Space Simulation Facility WSA/TVA
ESA Mission with Airbus DS UK as prime

1. Tasks

During space simulation tests, i.e. heat balance tests, the test object is exposed to a high vacuum, cold shroud and an artificial solar beam. The purpose of such tests is to determine the temperature distribution in the test object. The position of the specimen can be varied in relation to the solar beam. Heat balance tests are designed to check the results of theoretical thermal models. In some cases the solar simulation may be replaced by IR radiation.

Thermal vacuum tests, i.e. functional tests of the equipment in the test object at different temperatures in a high vacuum, mean to examine the function and performance data under extreme conditions and to detect possible manufacturing defects. Occasionally, such tests include thermal cycling between extreme temperatures in order to produce a certain ageing effect and thus exclude early breakdowns. IR radiation heating may be used to achieve high rates of temperature changes and for local temperature gradients in the test object.

Special measurements, e.g.:

- Deformation measurements under space conditions using videogrammetry
- Leak rate determination
- Outgassing measurements by means of mass spectrometers and / or micro balances

2. Test Facilities

There are four facilities available for thermal vacuum tests sized small, medium and large (see par. 3). Principally, these facilities consist of vacuum chambers equipped with oil free vacuum pumps and with thermal shrouds which can be supplied with liquid and / or gaseous nitrogen. The 2.5 m-He TVA is additionally equipped with a gaseous He cooling system which allows the cooling of shrouds down to cryo temperatures. Furthermore, the large facility (WSA/TVA) is equipped with a solar simulator providing a parallel solar beam of homogeneous intensity distribution.

Various means of mounting or suspending the test object are available; in case of the space simulation facility (WSA/TVA) the test object may be mounted on a two-axes motion simulator.

Measuring equipment includes several primarily computer-controlled data acquisition and data handling facilities from 50 to 1,000 channels for thermal data, various pressure instrumentation from ambient to high vacuum pressures, and mass spectrometers.

The facilities are located in building 33.1 (see Fig. 4). The test hall can be accessed via an air lock and a transport bay which connects to the test preparation areas and to other test facilities. The test hall is air-conditioned and free of dust particles corresponding to clean class ISO 8 (ISO14644-1). Adapted to the 2.5m-He Thermal Vacuum Facility a clean tent of clean class ISO 5 is also available. Adjacent to the test hall are the checkout rooms, with cable links to central checkout rooms and other test facilities as well as an uninterruptible power supply.

3. Technical Data

3.1 Space Simulation Facility WSA/TVA in Building 33.1

Test volume, length x diameter:	12 m x 6.2 m
Maximum mass of test object:	On motion simulator: - Basic trolley: 5,000 kg - Basic trolley with L-Adapter: 2,500 kg Without motion simulator: 10,000 kg
Shroud temperature:	< 100 K - 385 K
Vacuum pressure:	< 10^{-5} mbar
Collimated solar beam:	Maximum intensity: 1,950 W/m^2 Uniformity in test plane: ± 4 % Uniformity in test vol. (± 1.5 m): ± 5 % Circular beam 3.6 m Rectangular beam 3.05 m x 4.5 m
Motion simulator, rotation of:	Attitude axis: ± 200° Spin axis: up to 10 rev. per minute

3.2 Thermal Vacuum Facility 3 m TVA in Building 33.1

Test volume, length x diameter:	5.2 m x 3.2 m
Maximum mass of test object:	1,200 kg
Shroud temperature:	< 90 K - 433 K
Vacuum pressure:	< 10^{-5} mbar

3.3 Thermal Vacuum Facility 2m TVA in Building 33.1

Test volume, length x diameter:	2.3 m x 1.8 m
Maximum mass of test object:	500 kg
Shroud temperature:	< 100 K - 450 K
Vacuum pressure:	< 10^{-5} mbar

Special measures for decoupling of vibrations

3.4 Thermal Vacuum Facility 2.5 m He TVA in Building 33.1

Test volume, length x diameter:	2.7 m x 2.1 m
Maximum mass of test object:	1,000 kg
Shroud temperature:	≤ 10 K - 320 K
Vacuum pressure:	≤ 10^{-5} mbar
Clean tent's clean class (ISO14644-1)	ISO 5

3.5 Data Handling

Sensors:	Thermocouples Cu/Ko, Si-diodes, platin resistors, thermistors, voltage signals
Number of channels:	Up to 2,000 customer data up to 500 housekeeping data
Data Processing:	Monitoring and evaluation of measured data, limit detection, average calculation, online graphic, equilibrium determination, teletesting (STAMP), etc.

3.6 Additional Measuring Equipment

Mass spectrometer:	Range: 0 - 200 m/e
Quartz Crystal Microbalance:	Mass sensitivity: 1.96 x 10^{-9} g/cm² Hz
Infrared Spectroscope:	Sensitivity: 1 x 10^{-9} g/cm²
Particle Counter:	Range: 0.3 - 10 µm
Particle Fallout Meter:	Range: 3 - 2,000 PFO units

3.7 Infrared-Equipments

Irradiated areas:	3,825 mm x 2,460 mm 5,090 mm x 2,460 mm
Maximum Intensity:	6.7 kW/m²
Uniformity:	$< \pm 15$ %

3.8 Test Hall in Building 33.1

Preparation area:	220 m²
Main hall, height:	9 m
Side wing, height:	6.4 m

Entrance, height x width:	7 m x 6 m
Clean class (ISO14644-1):	ISO 8
Separate clean tent:	ISO class 5
Temperature:	22°C, ± 3°C
Relative Humidity:	55 %, ± 10 %
Uninterruptible power supply:	Max. 2 x 40 kW; cable links to different facilities and c/o rooms
Hoisting equipment (main hall):	Load: 5,000 kg Movement: (Up-Down) 12/1.2/0.15 m/min (North-South): 40/10 m/min (East-West): 21/5 m/min
Hoisting equipment (side wing):	Load: 1,600 kg Movement: (Up-Down) 8/0.8 m/min (North-South): 10/2.5 m/min (East-West): 14/3.5 m/min
Maximum load of floor:	15 kN/m

3.9 Checkout Room 1

Area:	76 m²
Height above false floor:	2.9 m
Hoisting capacity:	500 kg
Uninterruptible power supply:	Max. 20 kW
Air conditioning, power consumption:	25 kW
Maximum load of false floor:	20 kN/m²

3.10 Checkout Room 2

Area:	40 m²
Height:	3.1 m
Uninterruptible power supply:	Max. 20 kW
Air conditioning, power consumption:	25 kW
Maximum load of false floor:	20 kN/m²

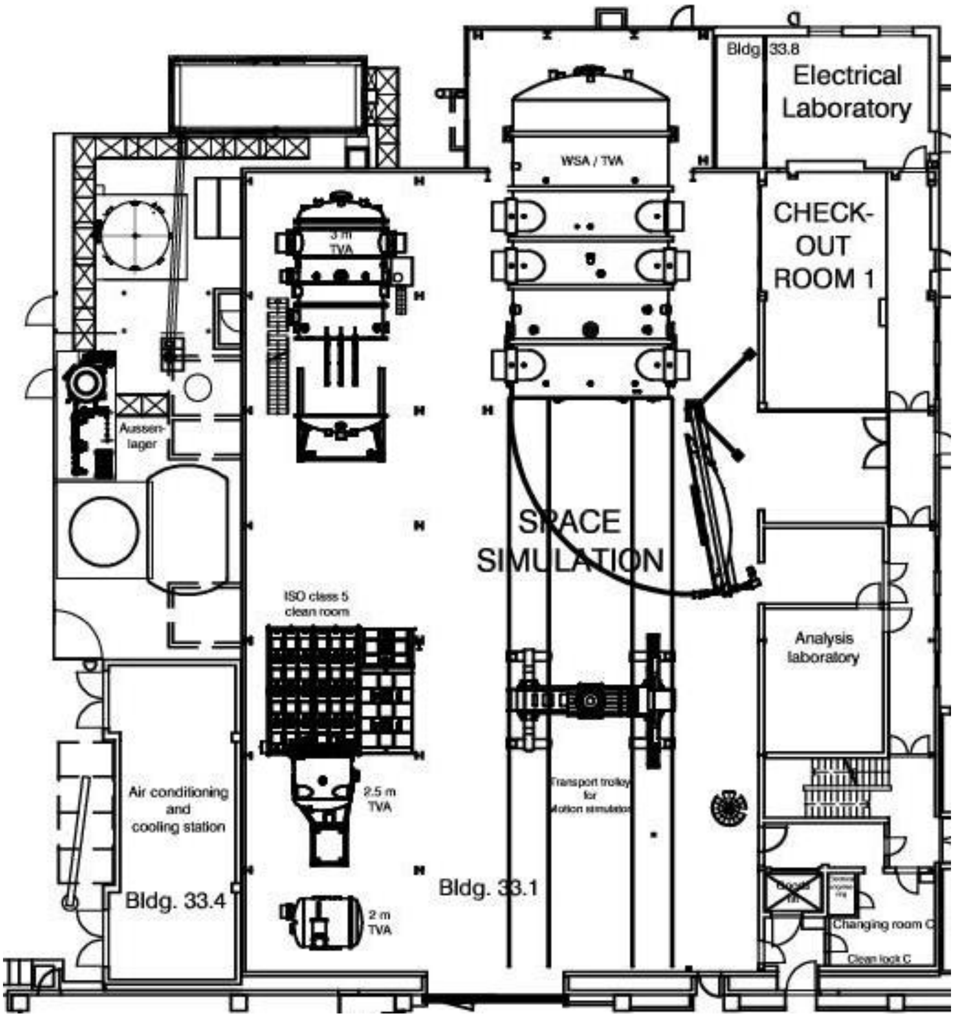


Fig. 5: Layout of Building 33.1

Space Division

Vibration and Shock Test Facilities

500 kN Multi-Shaker System with SENTINEL 2C S/C

1. Tasks

- Dynamic load tests for development and qualification
- Experimental simulation of real loads
- Measurements of real operational loads
- Analysis of dynamic processes and verification of model calculations
- Specialist advice

2. Test Facilities

The vibration and shock laboratory operates several vibration facilities with graded capacity and force vectors from 36 kN to 500 kN. The two biggest single shakers and a unique multi-shaker system are housed in an air-conditioned test hall which fulfils the clean room conditions of class 8.

The pyroshock simulation equipment is mobile and can be used in standard laboratory conditions as well as in ISO 8 clean conditions or even at customer premises.

A data acquisition system with 250 channels is available for measuring and evaluating the test object responses (extendable up to 1000 channels). The principal measurement values are acceleration, strain and force.

The digital measurement data can be transferred to customer work stations

which are equipped with the DynaWorks software for extensive post processing and prediction.

The smaller shakers are operated in another building under regular laboratory conditions. The vibration facilities are equipped with standard test fixtures and slip tables in order to expose the test objects to uniaxial loads in the three orthogonal axes. A dedicated force measurement device is available for system level tests on the 500 kN shaker system.

Three facilities with a force rating of up to 50 kN are equipped with thermal chambers in the range of -70° C to 190° C. The operating mode is both vertical and horizontal.

3. Technical Data

3.1 Multi-Shaker System (VVS)

Force rating:	500 kN sine, 460 kN random
Max. acceleration:	Bare standard table: 16 g With 1,000 kg payload: 10 g
Min. controllable level:	0.05 g
Max. displacement:	± 10 mm (sine)
Frequency range:	4 - 2,000 Hz (overall range)
Max. payload mass (table excl.):	4,000 kg (standard)
	10,000 kg (with additional pneumatic load compensation)
Usable surface area:	2.92 m x 2.92m (slip table)/3.18 x 3.18 m (head expander), with 80 x 80 mm² hole pattern, M10

3.1.1 Standard Fixtures

	Head expander	Slip table
Mass (incl. moving elements)	2,200 kg	1,900 kg
Max. Overturning Moment	150 kNm	1,100 kNm
Table surface level with respect to test floor	+0.93 m	-0.06 m

3.1.2 Force Measurement Device

Number of load cells:	16
Measurement range lateral:	480 kN
Measurement range vertical:	2,400 kN
Dedicated signal conditioners:	
Real-time summation unit for overall force and moment determination	

3.2 200 kN Vibration System

Force rating:	200 kN sine 168 kN random
Max. acceleration:	25 g
Min. controllable level:	0.05 g
Max. displacement:	± 15 mm
Frequency range:	5 - 2,000 Hz
Max. payload mass:	1000 kg (table excl.)
Usable surface area:	1.5 m x 1.5 m, with 80 mm x 80 mm hole pattern, M10

3.2.1 Standard Fixtures

	Head expander	Slip table
Mass (incl. moving elements)	485 kg	460 kg
Table surface level with respect to test floor	+2.05 m	+ 1.05 m

3.3 125 kN Vibration System

Force rating:	125 kN sine 115 kN random
Max. acceleration:	20 g
Min. controllable level:	0.05 g
Max. displacement:	± 10 mm
Frequency range:	5 - 2,000 Hz
Max. payload mass (table excl.):	500 kg
Usable surface area:	up to 1 m x 1 m
	with 40 mm x 40 mm, hole pattern, M8 or 80 mm x 80 mm hole pattern, M10

3.4 Vibration Control

Two digital control systems both equipped with

- LMS Test.Lab Software on a standard PC,
  excitation: sine, random, transient (classical shock & SRS)
- 48 input channels (pilots + limiter channels),
  on-line monitoring of selected channels,
  automatic notch and abort functions,
  external low-pass filtering,
  "easy link" (24 lines) to the data acquisition system
- Safety features:
  limitation of shaker input current (force)
  emergency button (soft shut-down)

3.5 Measurement Equipment

1,500 accelerometers (various types for specific applications), mainly ICP, with full scale ranges from mg up to 200,000 g

3.6 Data Acquisition and Processing

250 measurement channels (up to 1,000 are possible) for sine and random:	up to 2.5 kHz
210 measurement channels for transients:	up to 5.6 kHz
100 measurement channels for strain or force:	up to 2.5 kHz
Data base:	Universal-Files LMS-TDF-Files DYNAWorks Files

3.7 Pyroshock Simulation

Test frequency range:	100 - 20,000 Hz
Max. SRS level:	10,000 g
Signal sampling rate:	200 kHz

3.8 Test Hall (Buildings 34.0 and 34.1)

Area (see Fig. 5):	581 m² (230 m² and 351 m²)
Height of hall:	9.6 m and 14.9 m
Entrance, width x height:	3.4 m x 3.9 m and 6.3 m x 11.0 m
Max. load on test floor:	7.5 kN/m² and 10 kN/m²
Clean class (ISO14644-1):	ISO 8
Temperature:	22°C, ± 3°C
Relative humidity:	55 %, ± 10 %
200 kN and 125 kN systems:	
1. Hoisting Equipment:	Load: 3,200 kg Min. lifting speed: 30 cm/min Lifting height above test floor: 8.3 m
2. Hoisting Equipment:	Load: 10,000 kg Min. lifting speed: 40 cm/min or Load: 2 x 5,000 kg Min. lifting speed: 10 cm/min Lifting height above test floor: 8 m
500 kN Multi-Shaker system:	
3. Hoisting Equipment:	Load: 10,000 kg Lifting speed: 0 - 2 m/min Lifting height above test floor: 12.5 m Fork Lift: Load: 1,250 kg Lifting height: 2.9 m
Transport Devices:	Load: 2,000 kg
Power Supply:	3 x 400/230 V: 16, 32, 64 A 50 Hz 3 x 200/115 V ± 20 %: 14.5 A 60 Hz 3 x 200/115 V ± 20 %: 8.7 A 400 Hz

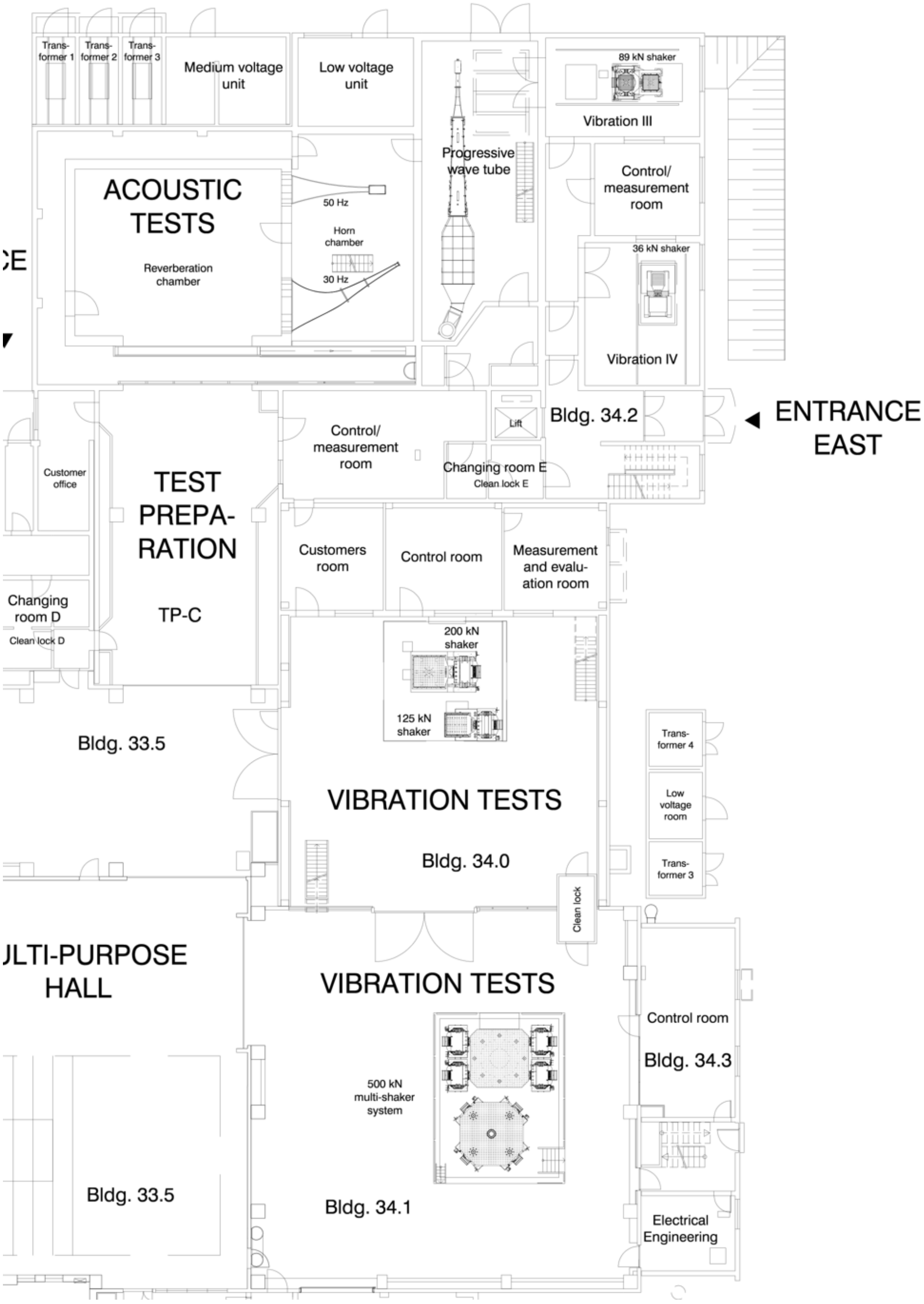


Fig. 6: Layout of Building 34.0/34.1 Vibration Facilities

Space Division

Modal Test Facility

Modal Survey Test on VEGA Launcher

1. Tasks

- Experimental and analytical vibration investigations, in particular supporting dynamic, acoustic, fatigue, and functional aspects during the development phase of equipment and products
- Determination of the modal characteristics of mechanical structures by test
- Test assisted development and verification of mathematical models
- Performance of micro-gravity qualification tests
- Measurement and analysis of operational vibration responses (e.g. modal analysis of vibration test data)
- Identification of critical excitations and vibration-susceptible structural areas
- Design and testing of remedial measures for vibration problems
- Optimisation of the dynamic behaviour of mechanical systems
- Consultancy in the field of structure dynamics

2. Test Facilities

Modal vibration exciters rated from 10 N to 7 kN for the excitation of test objects and a versatile test facility for the measurement and analysis of artificially or naturally excited dynamic responses are available for experimental vibration investigations.

The versatile modal test facility (VMT) incorporates test control, acquisition and analysis for the state-of-the-art phase resonance and phase separation methods. The facility can be scaled in units of 126 measurement channels to meet any test requirement up to 1,000 channels.

Particular features of the modal test facility are its exceptional frequency range of sine operation between 0.2 Hz up to 35 kHz and its automatic mode for force appropriation testing.

In addition, several DC powered mobile systems with up to 48 channels are available for in-vehicle operational vibration.

All systems are mobile and can be used at short notice at any test site. This equipment is complemented by a laser scanning vibrometer for contactless measurements of vibrations.

The modal test performance is computer controlled. The evaluation of the measured signals and the presentation of the test results are conducted with the help of sophisticated up-to-date software tools.

An air-conditioned test hall with clean conditions of ISO class 8 is available for the conduct of the investigations. The hall contains a seismic foundation for fixing the test objects.

3. Technical Data

3.1 Excitation

Sine wave generators:	Up to 30 kHz
Random noise generators:	Up to 25 kHz
Simultaneous control:	Sine and random: 12 channels
Vibration exciters:	10 N up to 7 kN
Instrumented hammers:	140 g up to 5 kg
Automatic hammer	2 g

3.2 Measurement

400 standard accelerometers:	Up to 5,000 m/s² and 10 kHz with sensitivity values ranging from 10 mV/g to 10 V/g
Additional transducers for displacement, force, pressure, strain and special environmental conditions, also further accelerometers can be made available.	

3.3 Data Acquisition

Sine:	
Up to 1,000 channels in parallel: Up to 500 channels in parallel	0.2 Hz - 10 kHz 0.2 Hz - 35 kHz
Random, general time signals:	
Up to 1000 channels in parallel: Up to 500 channels in parallel	0 - 20 kHz 0 - 40 kHz
Data base (for exchanging data):	Universal Files

3.4 Computers

Networked and standalone Windows work stations with Internet gateway.
Disk storage units, CD and DVD for data exchange
High quality colour printers / plotters

3.5 Test Hall

Area (see Fig. 8):	328 m²
Height of hall:	15 m
Entrance, width x height:	5.9 x 10 m and 6.3 m x 11.0 m
Maximum floor load:	20 kN/m²
Maximum block load on 2.5 m x 2.5 m:	250 kN
Clean class (ISO14644-1):	ISO 8
Temperature:	22°C, ± 3°C
Relative humidity:	55 %, ± 10 %
Test foundation (Fig. 8):	Area: 10 m x 13 m Mass: 250,000 kg
Anchor rails (HTA 72/48 mm):	Distance: 1 m Loading: 108 kN/m
Test hall crane: Lifting speed: Lifting height:	Max. Load: 10,000 kg 0 - 2 m/min 12 m
Power Supply:	3 x 400/230 V, 50 Hz 16, 32, 63 A

3.6 Standard Test Fixtures

Base plate 3.1 m x 3.1 m x 0.1 m with ARIANE 5 ACU hole pattern, rigidly fixed to the test foundation.

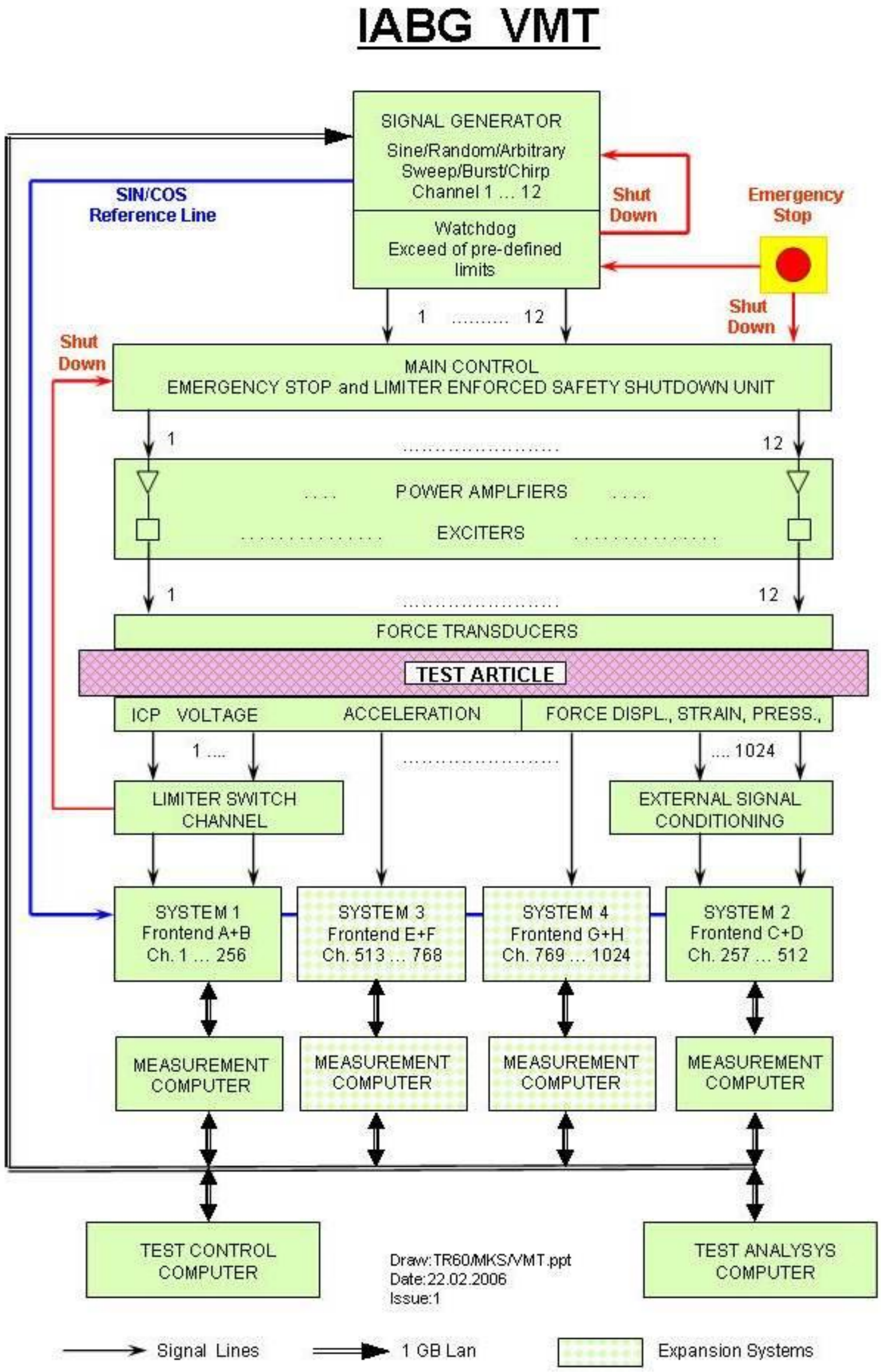


Fig. 7: Versatile Modal Test System (VMT)

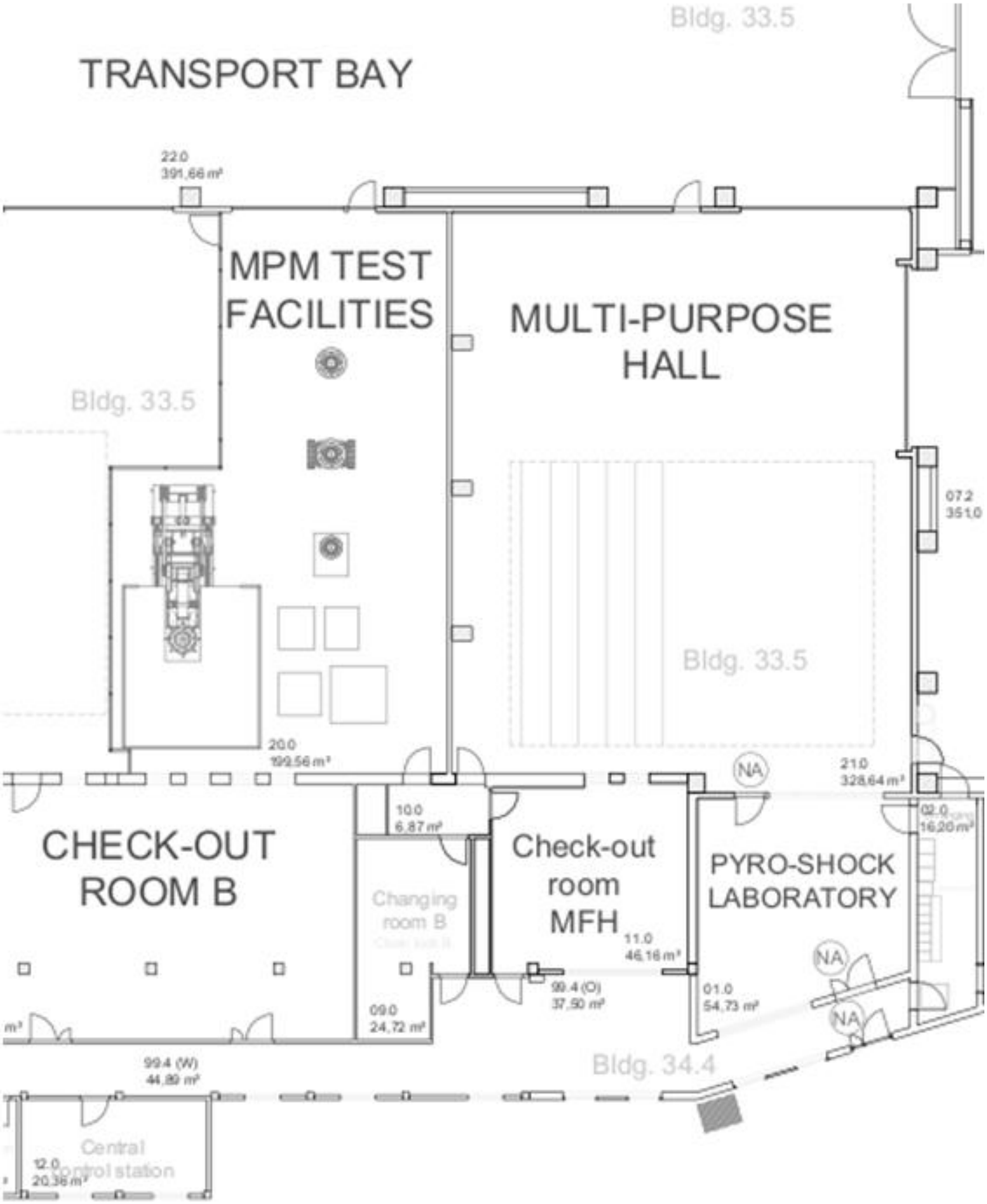
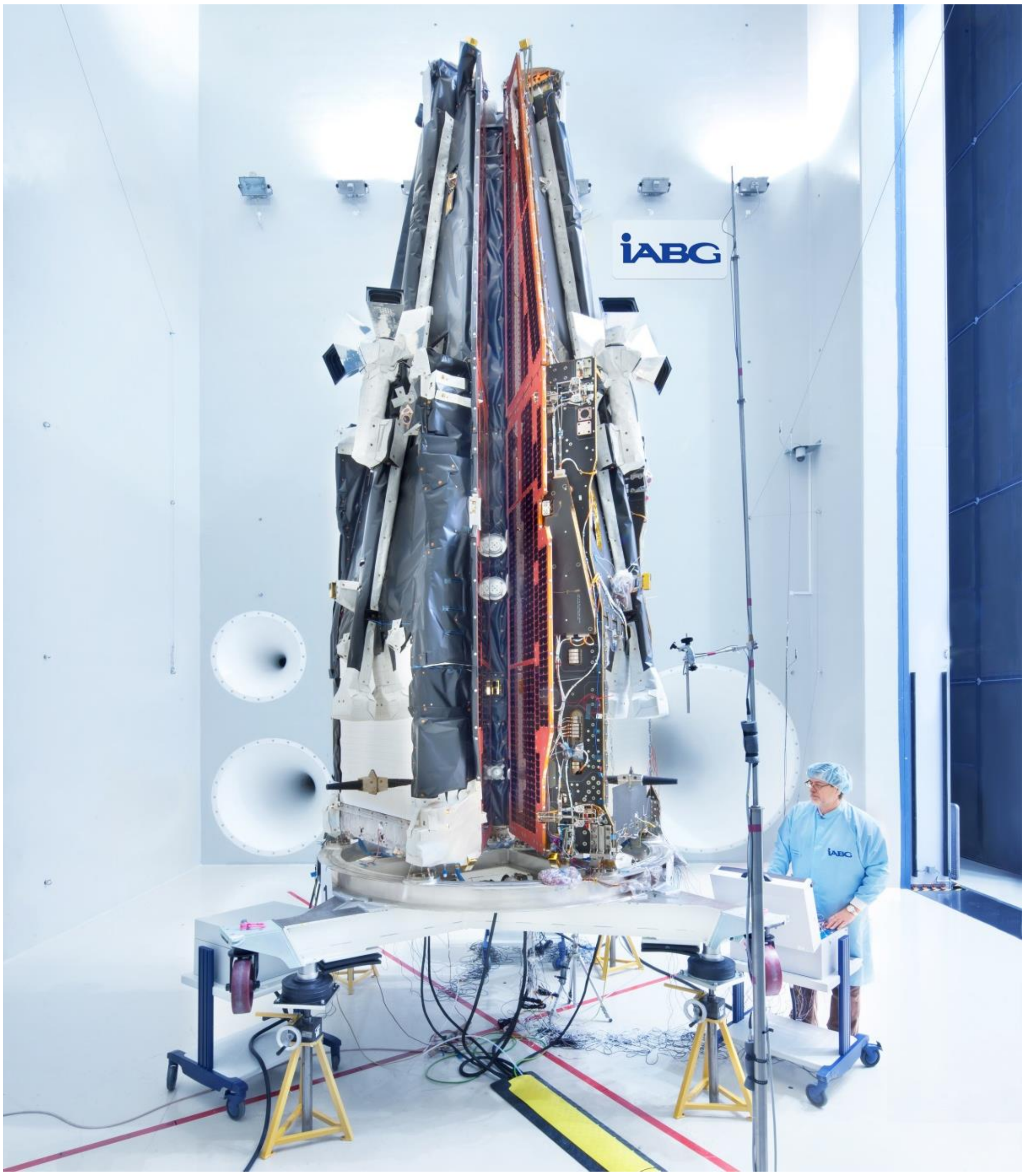


Fig. 8: Layout of Building 33.5, Multi Purpose Hall, e.g. used for structure tests

Space Division

Acoustic Noise Test Facility



SWARM S/C Stack in the Acoustic Test Facility

1. Task

Acoustic noise tests are performed to qualify the test object for the acoustic environments encountered during the mission of spacecraft. During launch, the most severe acoustic phases are the lift-off and the transonic regime. This severe acoustic environment is simulated in a reverberation chamber. In addition, fluctuating pressure fields, such as during atmospheric descent, are simulated in a special Progressive Wave Tube.

2. Test Facilities

Acoustic noise tests are performed in the acoustic facility with a reverberation chamber of V = 1,378 m³ (156 dB OASPL), or in a progressive wave tube for high intensity (170 dB OASPL) tests. These installations are directly accessible from the existing space test facilities (see Fig. 9) such that a test object must not leave the clean area when performing a series of qualification tests. In the reverberation chamber, the test object is exposed to a diffuse sound field with sound waves impinging from all directions. The noise generation system is based on three air compressors providing a maximum air flow of 6 kg/s for three noise generators and horns (see Fig.10). The test control and measurement system consists of 24 microphone channels and of 256 regular response acceleration and 64 strain channels in standard configuration and can be extended.

Test control is performed using an automatic control system.

In cases where the test object is to be excited from one side only, the use of the Progressive Wave Tube is favourable. In this case the test specimen is flush-mounted into one of the walls and excited by progressive waves inside the tube.

A separate control and measurement room, a preparation hall of a 110 m² area and a measurement room for customers form additional elements of the infrastructure.

3. Technical Data

3.1 Reverberation Chamber

Chamber, depth x width x height (cube):	8.9 m x 10.4 m x 15.2 m
Main door, width x height:	6.5 m x 15.2 m
Crane capacity:	16,000 kg
Clean class (ISO14644-1):	ISO 8
Temperature:	22°C, ± 3°C
Relative humidity:	55 %, ± 10 %
Max. acoustic power:	3 x 30 kW ac
OASPL (broadband):	156 dB
Acoustic spectrum:	25 Hz ≤ f ≤ 10 kHz
Duration of noise exposure:	Unlimited
Data acquisition and reduction:	24 microphone channels 256 response data channels up to 64 strain channels 1/1 oct.-, 1/3 oct.-, 1/12 oct.- PSD-Analysis RMS values, correlation and other statistical functions

3.2 Progressive Wave Tube

Test section:	0.8 m x 1.2 m
Max. acoustic power:	3 x 30 kW ac
OASPL (broadband):	170 dB
Acoustic spectrum:	25 Hz ≤ f ≤ 10 kHz
Duration of noise exposure:	Unlimited
Data acquisition and reduction:	12 microphone channels 48 response data channels up to 64 strain channels 1/1 oct.-, 1/3 oct.-, 1/12 oct.- PSD-Analysis RMS values, correlation and other statistical functions

3.3 Preparation Hall

Dimensions, area, height:	110 m², 15.2 m
Main door, width x height:	6.2 m x 9.9 m
Hoisting equipment:	1 crane bridge 16 t (running into the reverberation chamber) lifting height 11.6 m (13 m) overhead crane qualified to 156 dB OASPL
Temperature:	22°C, ± 3°C
Relative humidity:	55 %, ± 10° C
Clean class (ISO14644-1):	ISO 8

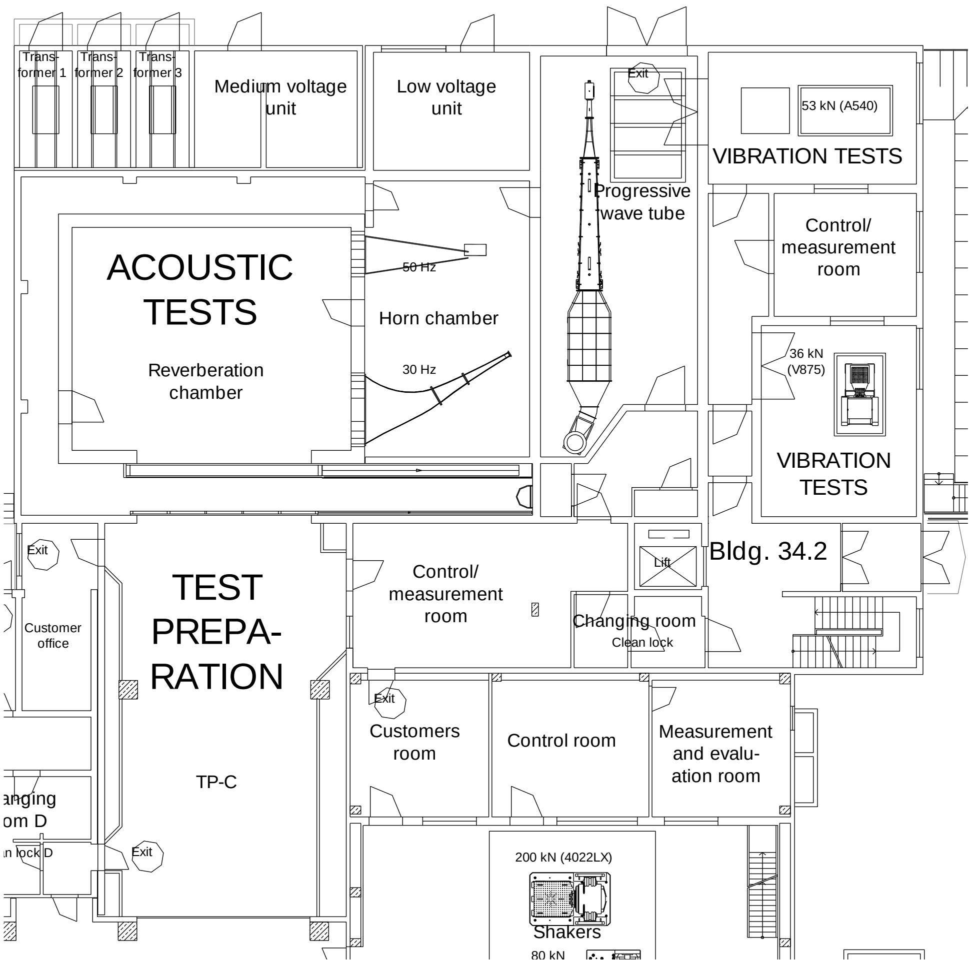
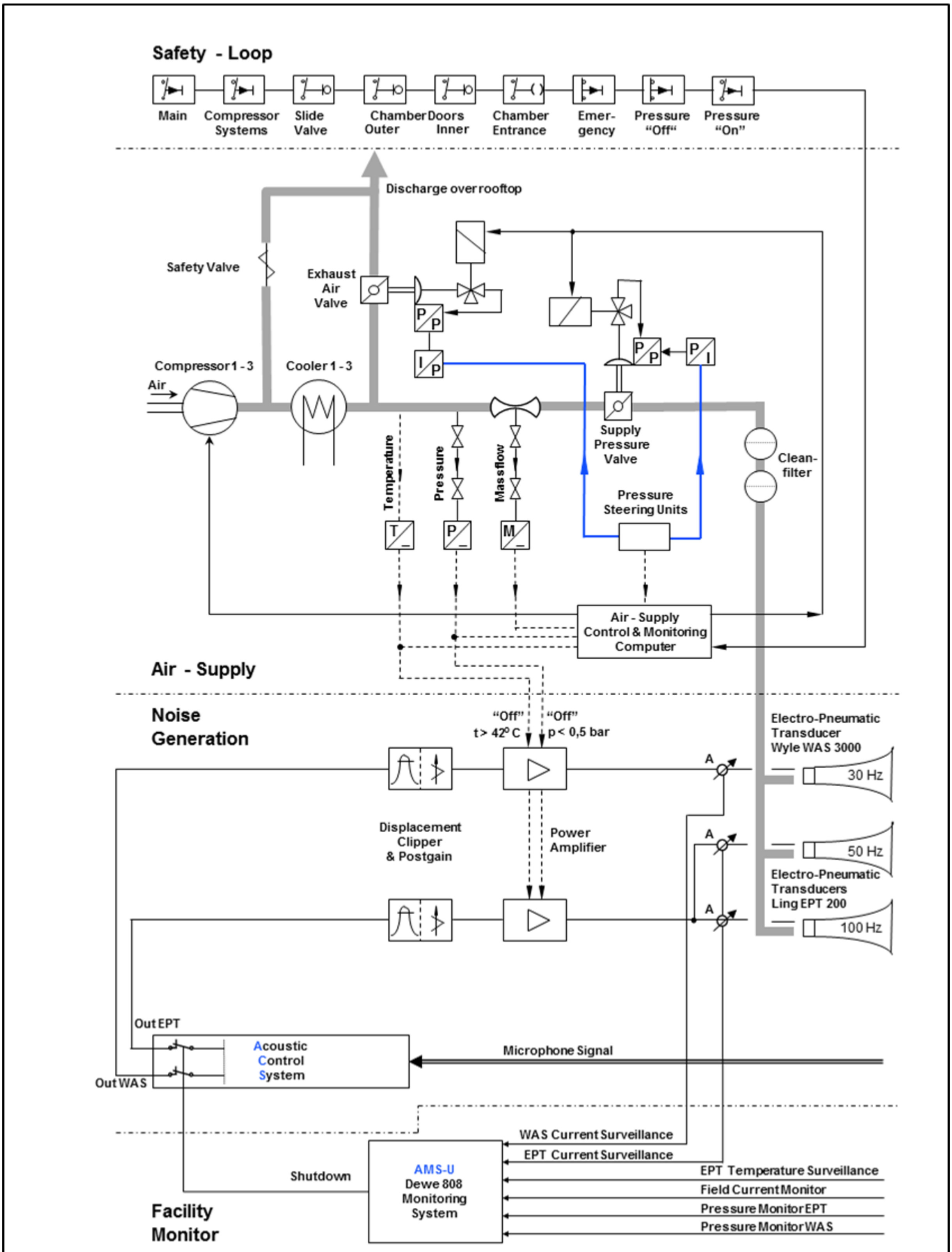


Fig. 9: Layout of the Acoustic Test Facility



LEGEND:		FILE:	Block Diagram - Reverberation Chamber – Noise Generation
(grey thick line)	Clean Compressed Air	AUTHOR:	F. Abt , T. Mc Kie
(solid line)	Analog Signal	DATE:	22.01.2014
(dashed line)	Digital Bus	REVISION:	5
(blue line)	Facility Compressed Air		

Space Division

EMC Test Facility

EMC Test on Sentinel 6 SAT-B S/C

1. Tasks

EMC emission and susceptibility testing in accordance with

- Space Standards such as ECSS-E-ST-20-07C and others
- Military Standards such as MIL-STD-461 A - G, VG 95373 and others
- Aviation Standards, such as RTCA/DO-160 A - G, AIRBUS, BOEING, EUROCOPTER
- Special customer requirements

- Emission and susceptibility test
- Measurement of shielding attenuation
- HIRF and indirect lightning effects
- Simulation of mobile communication on GSM Frequencies
- Power characteristics and simulation
- Consulting and Hardening

2. Test Facilities

The EMC test facilities are accredited by DAkkS (D-PL-12001-01-00) according to ISO/IEC 17025. and certified according to EN 9100.

The test facilities consist of one large shielded anechoic chamber with a shielded anteroom and two medium anechoic chambers with anteroom.

Emissions are measured with computer controlled EMI-Receiver Systems and FFT-Analysers.

By means of this equipment EMC tests can be conducted in the range from 10 Hz to 40 GHz in compliance with the applicable standards.

Generators, high-power amplifiers and special antennas are available to generate electro-magnetic fields of more than 4,000 V/m (depending on the frequency range). Transients, such as spikes, indirect lightning (LEMP), electro-static discharge (ESD), multiple burst and stroke can be simulated.

Electrical tests for simulation of power supply systems can be performed at variable frequencies (overvoltage, interruptions, surges).

3. Technical Data

3.1 Chamber Characteristics

	Large Anechoic Chamber	Medium Anechoic Chambers
Length x width x height:	10.5 m x 7.2 m x 8.2 m	5.4 m x 4.3 m x 2.7 m (EMV2) 4.6 m x 4.6 m x 2.7 m (EMV3)
Anteroom:	6.5 m x 9.0 m x 3.5 m	2.7 m x 6.3 m x 2.8 m (EMV2) 2.7 m x 5.5 m x 3.0 m (EMV3)
Max. floor load:	29 kN/m²	30.0 kN/m²
Single point load:	10.0 kN/m² unit	5.0 kN/m² unit
Dimensions of door, width x height:	6.0 m x 4.0 m	0.89 m x 1.9 m (EMV2) 1.0 m x 2.1 m (EMV3)
Clean class (ISO14644-1):	ISO 8	Visibly clean
Temperature:	22°C, ± 3°C	22° C, ± 3° C
Relative humidity:	55 %, ± 10 %	55 %, ± 10 %
Compressed air and water supply:	Available	Available
Exhaust tail pipe:	Available	-
Hoisting equipment:	Load: 5,000 kg Min. lifting speed: 30 cm/min	-
Fire detection system:	Available	Available
Fire fighting system:	Handheld Extinguisher	Handheld Extinguisher
Shielding attenuation:	H-field: 10 kHz > 60 dB above 1 MHz > 100 dB	H-field: 10 kHz > 60 dB 100 kHz > 70 dB above 1 MHz > 80 dB
Absorber reflectivity:	70 to 300 MHz > 19 dB 300 MHz - 40 GHz > 30 dB	Ferrite: 10 MHz - 1 GHz > 17 dB Pyramides: 100 MHz - 18 GHz > 20 dB
Power handling:	1 kw/m² (600 V/m) continuously	1 kW / m² (600 V/m) continuously

3.2 Equipment for Emission Tests

3.2.1 Frequency Domain

EMI Receivers	5 Hz - 40 GHz
Spectrum Analyzer	20 Hz - 50 GHz
Current Probes	10 Hz - 150 MHz
Active Rod Antennas	10 kHz - 50 MHz
Broadband Dipoles	25 MHz - 1 GHz
Circular Broadband Helix	200 MHz - 1 GHz
Std. Gain Horns	0.8 - 40 GHz
Double Ridged Horns	0.2 - 40 GHz
Passive Magnetic Loop	10 Hz - 150 kHz
Active Magnetic Loop	9 kHz - 30 MHz

3.2.2 Time Domain

Digital Storage Oscilloscope	4 GS/s
Digital Storage Oscilloscope	300 MHz
Data Recorders	
Differential Voltage Probes	DC - 200 MHz
High Voltage Probes	DC - 1 GHz
High Current Probes	DC - 50 MHz
High Speed Current Probes	ESD Currents

3.3 Equipment for Susceptibility Tests

3.3.1 Frequency Domain

RF generators and synthesizers		1 mHz - 40 GHz
AF Amplifier	2 kW	DC - 150 kHz
CW Amplifiers	2 kW 3 kW 750 W 500 W 200 W 5 W 320 W 1 W 40 W	10 kHz - 220 MHz 200 MHz – 1 GHz 200 - 500 MHz 500 MHz - 1 GHz 1 GHz - 8 GHz 1 GHz - 18 GHz 8 GHz - 18 GHz 18 GHz - 40 GHz 18 GHz – 40 GHz
Pulse Sources	4 kW 3 kW 2 kW 2 kW 2 kW	200 MHz - 500 MHz 500 MHz - 1 GHz 1 GHz - 2 GHz 2 GHz - 8 GHz 8 GHz - 18 GHz
TEM Cell		10 kHz - 300 MHz
Parallel Plate Antenna		10 kHz - 200 MHz
Stripline		10 kHz - 200 MHz
E-Field Generator		10 kHz - 30 MHz
Logper Antenna		100 MHz - 200 MHz
BiLogper Antenna		30 MHz - 1 GHz
Std. Gain Horns		800 MHz - 40 GHz
Double Ridged Horns		200 MHz - 40 GHz
B-Field Indicator		10 Hz - 30 kHz
E- Field Indicator		10 kHz - 50 GHz
Current Injection Probes		10 kHz - 400 MHz
Current Monitor Probes		DC - 1 GHz
LISNs		DO-160 ; MIL ; EFA
Coupling Device		AF-Transformer 2:1
Induced Signal (Voltage)		Transformer 12 kV
Induced Signal (Current)		Transformer 120 A
Susceptibility Software		RSUS

3.3.2 Time Domain

Arbitrary Generator		DC - 20 MHz
Bipolar Operational Amplifier	2 kW	DC - 150 kHz
CS06 MIL-STD-461C/462	± 1kV	Spike 150 ns, 10 µs
CS115 MIL-STD-461/462D,E		Spike 30 ns
CS116 MIL-STD-461/462D,E	10 A	Damped Sinus 10 kHz - 100 MHz
Half Sine		5 µs
Fast Pulse EFA		0.1/2 µs
Slow Wave Airbus (Single Stroke)		40/95 µs
Fast Wave Airbus (Single Stroke)		1/10 µs
Long Wave (Single Stroke)		2/50 µs
Communication Pulse		
Lightning - Single Stroke - Multiple Stroke - Multiple Pulse - Multiple Burst	 Level 5 Level 5 Level 5 Level 5 Level5 Level 5	Waveforms: wave 1: 6.4/70 µs (I) wave 2: 0.1/6.4 µs wave 3: 1 MHz/10 MHz wave 4: 6.4/70 µs (U) wave 5A: 40/120 µs wave 5B: 50/500 µs wave 6: 0,25/40 µs
Voltage Spike AMD24 (LD104, SVF104 etc.) and ABD0100.1.8.1		10 µs, 50 µs, 100 µs, 400 µs
ESD		Networks: 150pF/330Ω (30kV, Air) 150pF/150Ω (30kV, Air) 100pF/1.5 kΩ (16kV, Air)
Burst (EN 61000-4-4)	5 kV	
Surge (EN 61000-4-5)	5 kV	1,2/ 50 µs

3.4 Power Supply for Customer Equipment and Test Articles

Mechanical Converter	3 x 115/200VAC 40 kVA, 400 Hz, ⅄ and △
Switched DC/AC Supply	3 x 0-200 V DC/AC 90 kVA, DC - 2 kHZ without N, only △
Programmable DC/AC Supply	3 x 0-400 V DC/AC 15 kVA, DC - 1 kHz, ⅄ and △
Programmable DC/AC Supply	3 x 0-400 V DC/AC 45 kVA, DC - 1 kHz, ⅄ and △
DC Power Supplies	0 - 60 VDC 30 A
	0 - 150 VDC 15 A
	0 - 40 VDC 250 A

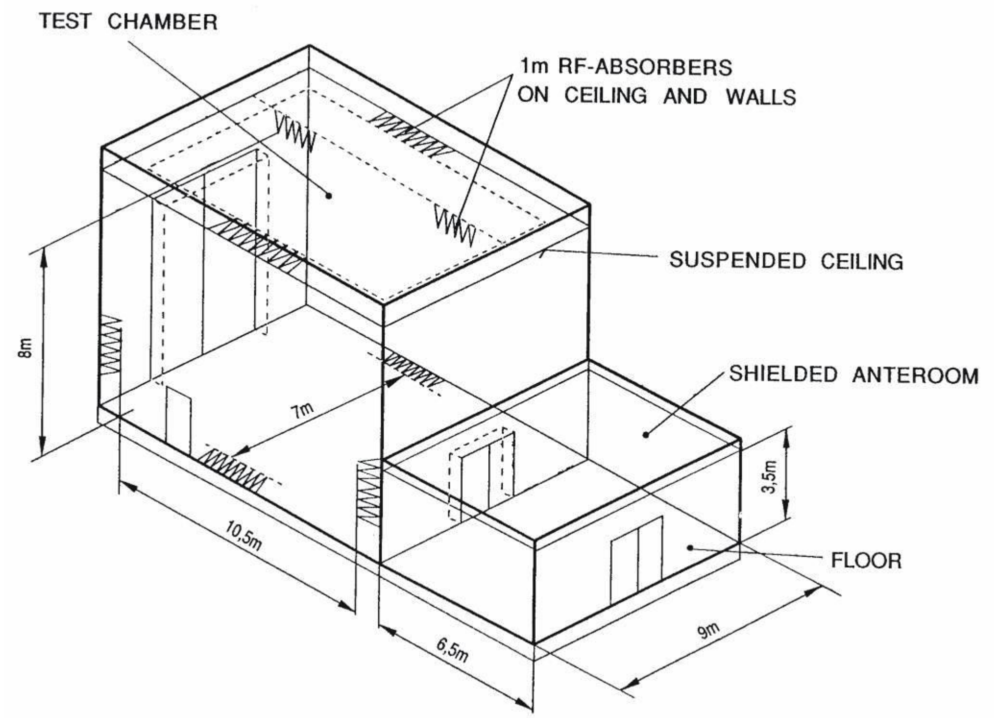


Fig. 10: Large EMC Anechoic Chamber (EMV1)

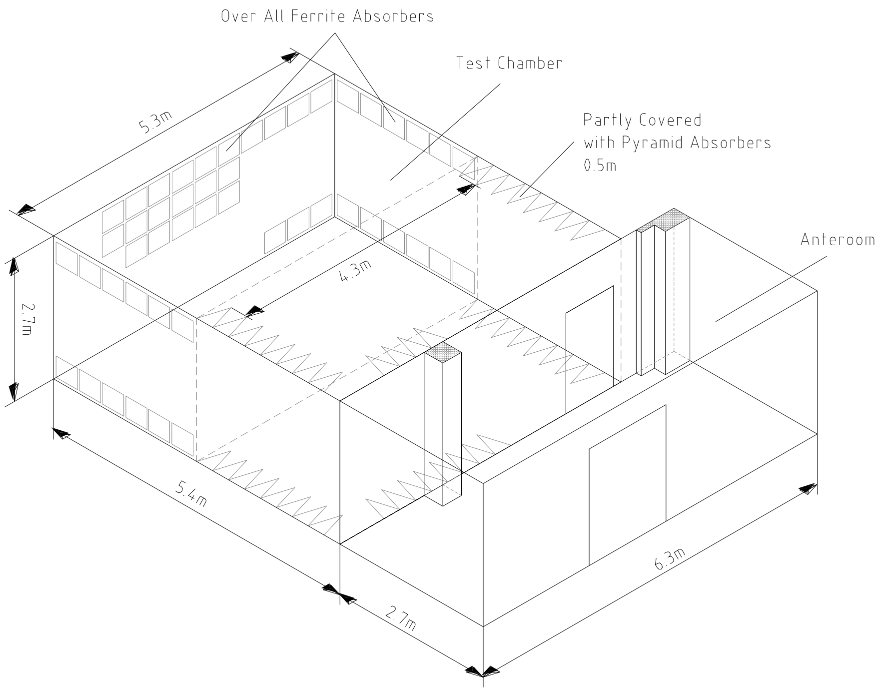


Fig. 11: Medium EMC Anechoic Chamber (EMV2)

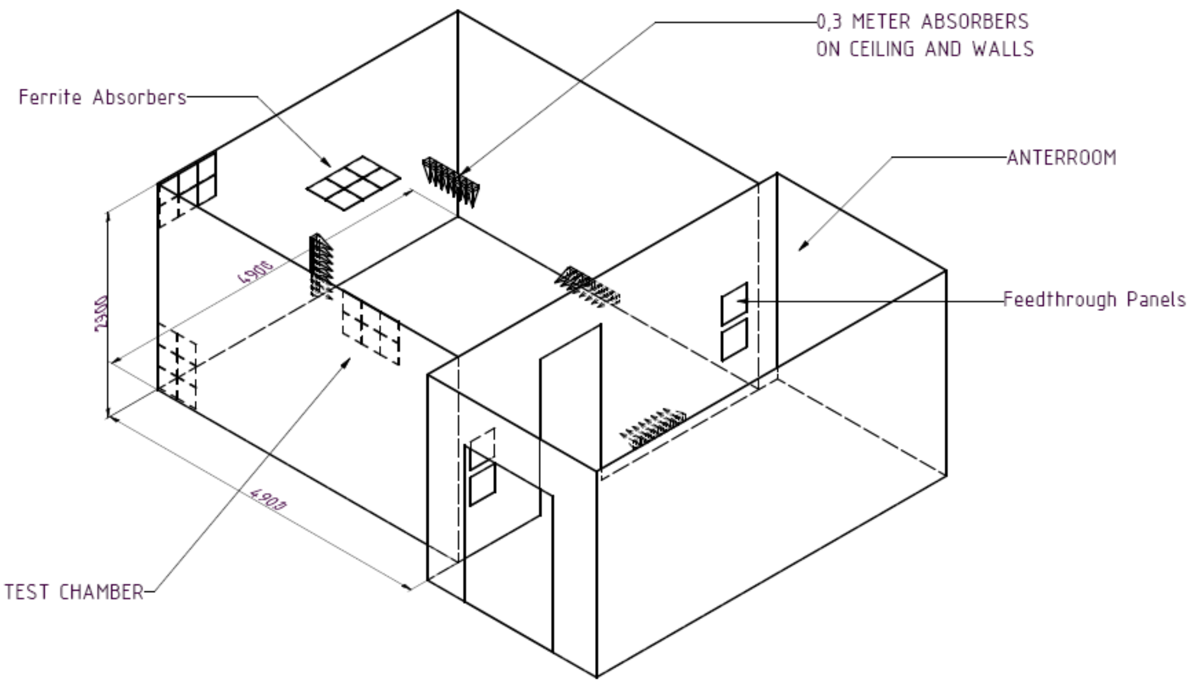


Fig. 12: Medium EMC Anechoic Chamber (EMV3)

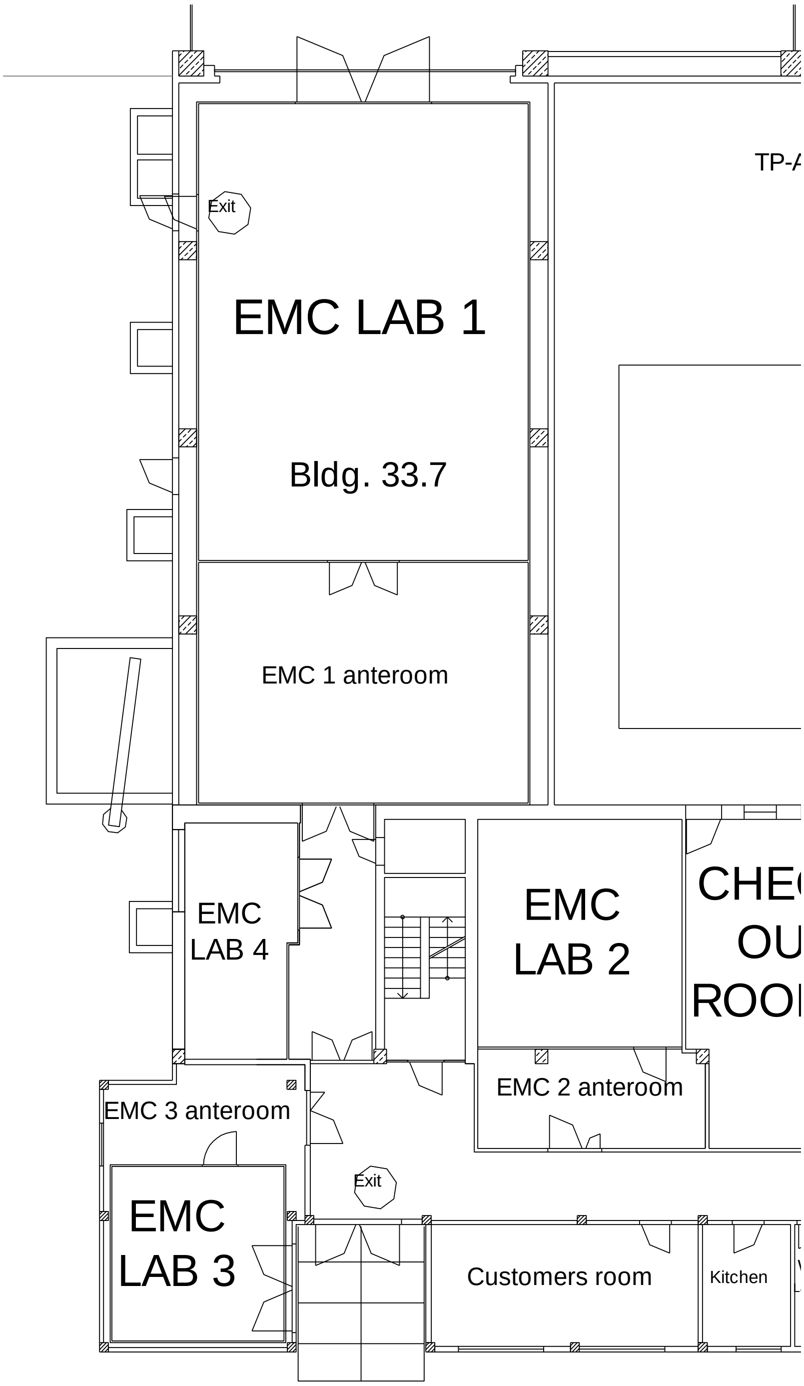


Fig. 13: Layout of the EMC Test Facilities

Space Division

Magnetic Test Facility

SWARM S/C during a magnetic test

1. Tasks

- Measuring the DC and AC magnetic cleanliness of test objects
- Magnetising and demagnetising of test objects to determine permanent, remanent and induced magnetic fields
- Measuring the dipole/multipole field distribution surrounding the test objects
- Modelling and predicting of far fields of a test object
- Modelling DC magnetic fields of a spacecraft based on several unit measurements
- Technical consulting for magnetic cleanliness
- Measuring magnetic moments
- Measuring eddy current fields
- Attitude control testing of magnetically stabilised spacecraft systems
- Calibrating magnetometers
- Magnetic Effect Test (RTCA/DO160)
- EN 61000-4-8/9/10 up to 1,000 A/m
- ISO 10373 and ISO 7816 800 kA/m
- Immunity at 16 2/3, 50 and 400 Hz

2. Test Facility

The magnetic test facility consists of a non-magnetic wooden building of 8,000 m^3 in size. The facility was built in a location free of earth field gradient, far enough from major sources of disturbance such as industrial areas, railways and power lines. The core of the facility consists of an aluminium structure supporting a 3-axial coil system with 4 coils per axis, capable of producing static and dynamic field vectors in any direction or a

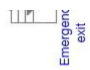


Fig. Test articles are located in the centre of the coil system where high precision magnetic measurements can be performed in an area of 4 m x 4 m x 4 m.

Test objects for space application can be tested under clean conditions of ISO class 8 and controlled environmental parameters.

3. Technical Data

3.1 Large Coil System

Type:	Square coil system, 4 coils per axis, 3 orthogonal axes
Dimensions:	15 m x 15 m x 15 m, free access area 4 m x 4 m
Zero field:	Compensation of the earth's field with a resolution of 0.1 nT Uniformity of created magnetic field: 5.0 nT in 0,5 m diameter, *1 Stability of facility: 1.5 nT/hour
D.C. field:	Range: 0 - 75,000 nT in each axis with a resolution of 0.1 nT Accuracy: 1 nT
A.C. field:	Frequency range: 0.01 - 3 Hz Amplitude range: 0 - 75,000 nT resp. 100,000 nTHz *2
	Frequency range: 3 - 3,600 Hz Amplitude range: 0 - 10,000 nTHz

**1 Additional external generated magnetic field gradients have to be taken into account separately.*
**2 nTHz is a unit related to the induction law: U = - dB/dt: i.e. voltage is change of the flux density per second. Example: 1,000 nTHz is equal to 1 nT at 1,000 Hz or 1,000 nT at 1 Hz.*

3.2 Magnetisation and Demagnetisation

Square Helmholtz coil system	
Dimension:	3.7 m x 3.7 m, horizontal field
Uniformity:	30 % in 3.0 m diameter, horizontal field
Magnetisation:	With D.C. fields of 1 - 4,000 A/m.
Demagnetisation:	With A.C. fields Start. amplit. of 160 - 4,000 A/m
Duration of demagnetisation:	Depending on requirements, typically 10 min
Residual field:	< 0.25 A/m

Further coil systems and power supplies exist for different demagnetisation volumes and levels.

3.3 Magnetometer *

Fluxgate magnetometer with triple or single probes (second harmonics measurement)	
DC application:	Range: 0 - 1 mT Accuracy: 0.1 % resp. 100 pT Resolution: 0.2 pT
Protonspin magnetometer (Nuclear precision)	
DC application:	Omnidirectional Range: 20,000 - 120,000 nT Accuracy: 0.3 nT Resolution: 10 pT
Search coil magnetometer (ferrite loop antenna)	
AC application:	Frequency range: 0.034 Hz - 30 KHz Amplitude range: 200 µT Sensitivity: 24 mV/µT

***** *for details please refer to STL data sheet*

3.4 Test Hall

Dimensions, length x width x height:	20 m x 20 m x 20 m
Entrance:	~ 5 m x 5 m
Clean class (ISO14644-1):	ISO 8
Temperature:	22°C ±3°C
Relative humidity:	55% ±10%
Crane in entrance hall on rail:	Approximately 16 m long Load: 5,000 kg Lifting height: 5 m
Hoist above centre of facility:	Load: 1,000 kg Lifting height: 10 m
Trolley large:	Load: 4,500 kg Movable on rails through facility and entrance hall
Trolley medium:	Load: 1,500 kg Movable on rails through facility and entrance hall Equipped with turntable

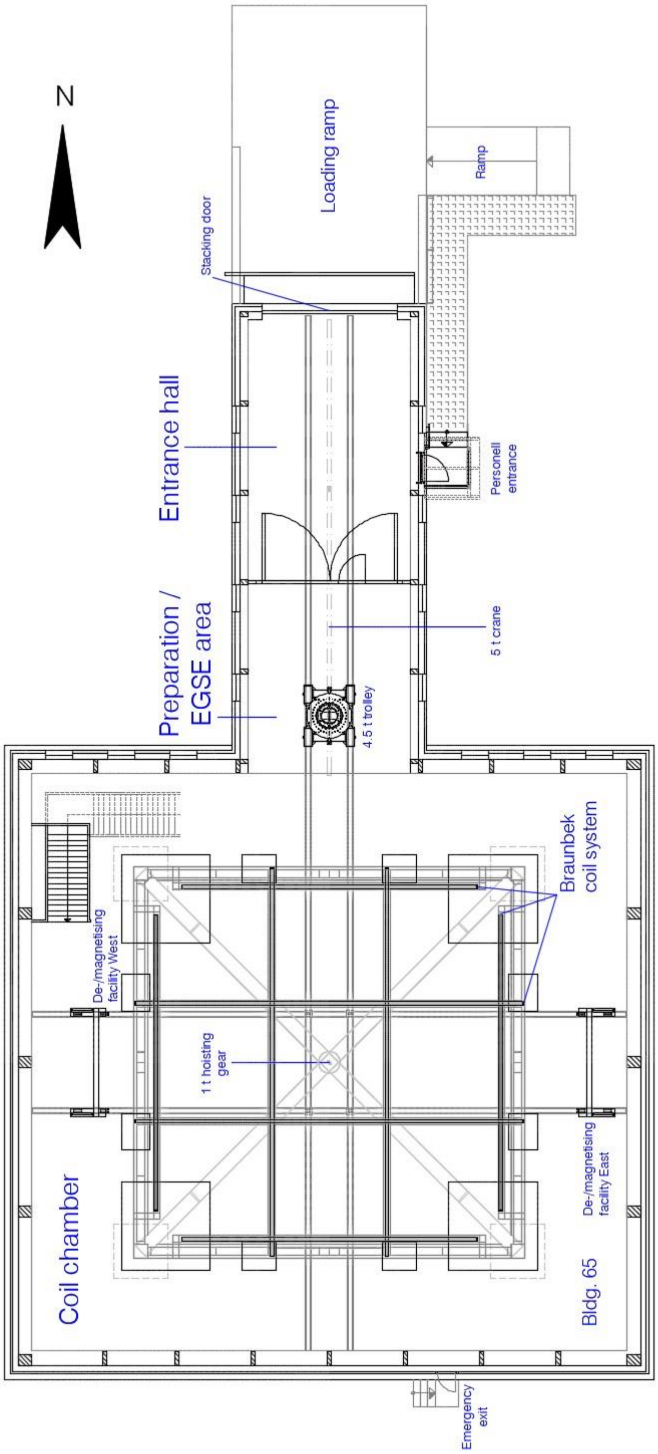


Fig. 14: Schematic Diagram of Magnetic Test Facility MFSA

Space Division

Mass Property Measurements

SOLAR ORBITER on the Mass Property Measurement Device
ESA Mission with Airbus DS UK as prime

1. Tasks

For satellites, space probes, launcher parts, their subsystems and payloads, or for any kind of general engineering systems a complete set of facilities is available for the accurate determination of the mass properties.

They comprise:

- Mass (weight)
- Centre of gravity (CoG)
- Moment of inertia (MoI)
- Product of inertia (PoI)

Furthermore, static and dynamic balancing or the determination of residual unbalances can be performed.

2. Test Facilities

For any kind of mass property measurement at least two measuring devices with different load capacities and measurement ranges are available. Therefore, the most suitable test equipment can be used for a specimen in order to meet various weight, dimension and accuracy requirements.

Six different high precision weight scales provide accuracies between 0.003 % and 0.03 % of the specimen's mass. This precise measurement is fundamental for further exact mass property determinations.

The centre of gravity (CoG) of a specimen can be determined with two different CoG scales. One can be used for small sized and light parts, the other one is capable of carrying specimen up to system level.
The WM50/6 – M7 device enables determination of the CoG and the MoI (moment of inertia) by using the same attachment plane. This allows the performance of two different types of tests without changing the test set-up.

Beside this combined machine another oscillation table with different accuracy and loading capacity is available for MoI determination.

For CoG measurements with respect to the specimen's vertical axis and for MoI measurements with respect to axes in the horizontal plane two L-shaped adapter with rotatable interfaces are available. They enable the fixation of the horizontally orientated specimen and therefore the measurement of the longitudinal CoG axis and MoI measurements around the lateral axes. In this way also the specimen's principal axes. respectively the product of inertia (PoI) about the lateral specimen axes can be determined.

The test specimen can be attached to the "L-Adapter" at the specimen's transport position (i.e. vertical). The L-adapter turning equipment (LATE) is capable to rotate the L-Adapter together with the test specimen into horizontal position and vice versa. With the L-Adapter lifting device (LLD) the L-Adapter can be lifted onto the MPM machines together with the specimen.

The MPM facilities also provide one balancing machine. A typical application of a balancing test is the elimination of static and/or dynamic unbalances, the measurement of residual unbalances or the determination of the PoI with respect to the (vertical) spin axis.

3. Technical Data

3.1 Weight Scales

There are six weight scales available with the following characteristics:

Weight Range:	Accuracy:
up to 8 kg	± 0.5 g
up to 60 kg	± 2.0 g
up to 600 kg	± 20.0 g
up to 1,000 kg	± 100.0 g (up to 600 kg ± 50 g)
up to 3,000 kg	± 200.0 g (up to 1,000 kg ± 100 g)
up to 6,000 kg	± 200.0 g

3.2 Centre of Gravity Scales

Weight Range:	Best achievable accuracy:
0.7 - 20 kg	± 0.3 mm
20 - 6,000 kg	± 0.5 mm (up to 50 kg ± 1 mm)

3.3 Oscillating Tables for MoI

MoI Range:	Best accuracy:	Weight:
0.05 - 0.1 kgm^2	± 2 %	small equipment
0.1 - 1.0 kgm^2	± 1 %	small equipment
1.0 - 2,000 kgm^2	± 0.5 %	2,000 kg
150 - 17,000 kgm^2	± 0.5 %	6,000 kg

3.4 Balancing Machines

Weight Range:	Rotation Speed:	Accuracies:
Up to 2,800 kg	20 - 160 RPM	0.14 - 7.0×10^{-4} kgm 0.20 - 7.0×10^{-4} kgm^2

3.5 Test Hall

Hall area:	200 m²
Height:	15.3 m
Door from transportbay: Door via TP-B:	5.1 m x 7 m 6.0 m x 10.0 m
Clean class (ISO-14644-1):	ISO 8
Temperature:	22°C, ± 3°C
Relative Humidity:	55 % ± 10 %
Max. floor load:	20 kN/m²
Crane, hoisting capacity:	10,000 kg
Crane max. height of hook:	11.6 m

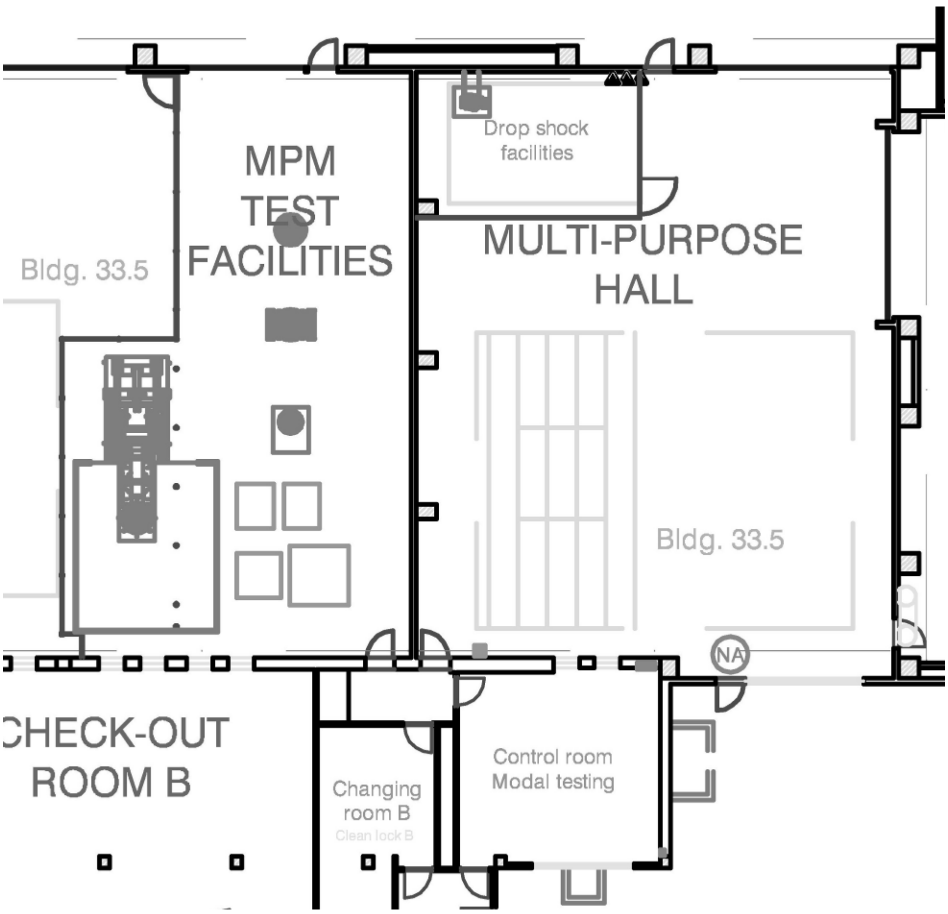


Fig. 15: Layout of the MPM Test Facility

Space Division

Calibration Facilities

Sinusoidal Calibration of an Accelerometer

1. Tasks

IABG provides facilities for calibration of:

- Multimeters
- Resistors
- Current probes
- Counters
- Temperature probes
- Thermocouple reference junctions
- Dynamic motion measuring transducers, electronics and systems
- Accelerometers
- Charge amplifiers

There are facilities for sinusoidal and shock calibration of accelerometers available. In both cases a comparison method is used, i.e. the calibration is related to a reference standard. These primary standards are calibrated optically by interferometric methods at the National Metrology Institute PTB (Physikalisch Technische Bundesanstalt).

2. Calibration Procedures

The calibration procedure to be applied is depending on the quantity metered or on requirements specified by the customer. It can be performed according to either AQAP6, MIL-STD-45662 or DAkkS procedures.

The Space Division at IABG provides a DAkkS accredited calibration laboratory for vibration instruments (D-K-12001-01-00).

Under the roof of the DAkkS (Deutsche Akkreditierungsstelle) as the national accreditation body calibration laboratories of industrial companies, science institutes, technical authorities, safety engineering and test institutes prove their capability to work according to the regulations of DIN EN ISO/IEC 17025.

The DAkkS calibration certificates are proof of the traceability to a national standard and meet, aside from this, other technical and administrative rules for the laboratory which are regulated within EN 9100 and DIN EN ISO/IEC 17025.

DAkkS accredited laboratories guarantee high quality calibrations and in consequence best reliability of measuring equipment. The use of DAkkS calibrated measuring equipment increases the confidence of the customers and the competitiveness on the national and international market.

3. Calibration Facility Performance

3.1 Electric Quantities

Quantity:	Range:	Notes:
DC - Voltage	0,01 mV - 1,000 V	
DC - Resistance	0.1 Ω - 100 MΩ	
DC - Current	0.1 µA - 250 A	
AC - Voltage	1 mV - 1,000 V	Frequency: 10 Hz - 1 MHz (20 Vmax.)
AC - Current	0.1 mA - 2 A	Frequency: 10 Hz - 5 kHz
AC - Current	1 A - 60 A	Frequency: 40 Hz - 500 Hz
Frequency	100 kHz, 1 MHz, 10 MHz	

3.2 Thermal Quantities

Quantity:	Range:	Notes:
Temperature	-80° C - 250° C	Calibration of small sized (12 litres) temperature probes
	-196° C and 0° C	Calibration at fix point temperatures with high accu-racy
Thermal response time		For small sized probes

Note: Extended calibration ranges can be made available upon request.

3.3 Sinusoidal Calibration of Accelerometers (Mid Frequency Range)*

Frequency range:	10 - 10,000 Hz	
Amplitude range:	Up to 10 mm peak-to-peak or 200 m/s^2	
Accelerometer mass:	< 100 gr	
Excitation:	Electrodynamic shaker	
Measurement uncertainty:	At 80 and 160 Hz:	0.5 %
	10 Hz - 5,000 Hz:	1 %
	5,000 Hz - 10,000 Hz:	2 %

Calibration method:	Comparison of acceleration levels using a traced calibrated reference accelerometer
Documentation:	DAkkS calibration certificate including: Sensitivity at customer defined frequency (normally 80 Hz) and excitation (normally 10 g) plot of normalised sensitivity: Expressed in % units in the frequency range of 10 Hz - 10 kHz expressed in dB units to indicate the main resonance frequency and any local resonances in the frequency range from 4 Hz - 50 kHz (not accredited).

** This calibration method is accredited by DAkkS and directly traceable to national standards.*

3.4 Sinusoidal Calibration of Accelerometers (Low Frequency Range) *

Frequency range:	0.5 - 100 Hz	
Amplitude range:	Up to 150 mm peak-to-peak or 10m/s²	
Accelerometer mass:	< 100 gr	
Excitation:	Electrodynamic shaker	
Measurement uncertainty :	0.5 - 1 Hz	0.8 % (sensitivity) 0.5 degree (phase)
	1 - 20 Hz:	0.5 % (sensitivity) 0.5 degree (phase)
	> 20 - 100 Hz :	0.8 % (sensitivity) 2 degree (phase)
Calibration method:	Comparison of acceleration levels using a traceable calibrated reference accelerometer	
Documentation:	DAkkS calibration certificate including: Sensitivity at customer defined frequency (normally 8 Hz or 80 Hz) and excitation (normally 0.5 g) plot of normalised sensitivity expressed in % or dB units or phase angle in degrees	

** This calibration method is accredited by DAkkS and directly traceable to national standards.*

3.5 Shock Calibration of Accelerometers (Low Amplitude Range)*

Acceleration range:	200 - 100,000 m/s^2	
Accelerometer mass:	< 50 gr	
Pulse shape:	Half-sine pulse	
Duration of pulse:	Depends on level: Approx. 3 ms at 200 m/s^2 Approx. 100 µs at 100,000 m/ s^2	
Measurement uncertainty :	200 - 1,500 m/s^2: > 1,500 - 5,000 m/s^2: > 5,000 - 100,000 m/s^2:	1 %* 1.5 %* 5 %*
Excitation:	Pneumatically operated projectile (POP) to impact a cylindrical anvil to which the reference and the test accelerometer are attached	
Calibration method:	Comparison of peak acceleration using a traceable calibrated reference accelerometer	
Documentation:	DAkkS calibration certificate including: Sensitivity i.e. mean value of 10 measurements at one acceleration level selectable by the customer	

** This calibration method is accredited by DAkkS and directly traceable to national standards.*

3.6 Calibration of Charge and Voltage Amplifiers*

Frequency range:	0.5 Hz - 50 kHz	
Amplitude Range:	0.1 pC - 10,000 pC 1 mV - 30 V	
Measurement uncertainty :	0.5 Hz - 10 kHz > 10 kHz - 30 kHz > 30 kHz - 50 kHz	0.3 % 0.6 % 1 %
Documentation:	DAkkS calibration certificate including: Transfer factors and plots of normalised frequency response expressed in % or dB units	

** This calibration method is accredited by DAkkS and directly traceable to national standards.*