



Accelerating  
the future  
of aerospace

# Environmental testing of aerospace equipment



Royal NLR - Netherlands Aerospace Centre

## Netherlands Aerospace Centre

NLR is a leading international research centre for aerospace. Bolstered by its multidisciplinary expertise and unrivalled research facilities, NLR provides innovative and integral solutions for the complex challenges in the aerospace sector.

NLR's activities span the full spectrum of Research, Development, Test & Evaluation (RDT & E). Given NLR's specialist knowledge and facilities, companies turn to NLR for validation, verification, qualification, simulation and evaluation. NLR thereby bridges the gap between research and practical applications, while working for both government and industry at home and abroad.

NLR stands for practical and innovative solutions, technical expertise and a long-term design vision. This allows NLR's cutting edge technology to find its way into successful aerospace programs of OEMs, including Airbus, Embraer, Pilatus and SME's like Fokker and Airborne. NLR contributes to (military) programs, such as ESA's IXV re-entry vehicle, the F-35, the Apache helicopter, and European programs, including SESAR and Clean Sky 2.

Founded in 1919, and employing some 650 people, NLR achieved a turnover of 73 million euros in 2014, of which three-quarters derived from contract research, and the remaining from government funds.

For more information visit: [www.nlr.org](http://www.nlr.org)

# INTRODUCTION

With our wide range of test facilities we can simulate your environmental testing requirements for your spacecraft or aircraft equipment, meeting international, military, aircraft and commercial standards.

Regardless of the environment that has to be simulated, NLR is the 'one stop shop' for all your testing needs. We will conduct your environmental tests for climatic, thermal vacuum, mechanical, electric, radiation and acoustics properties.





## NLR Environmental test facilities



# CLIMATE TEST CHAMBERS

The Test House of the Structures Testing & Evaluation department operates climate test chambers for carrying out a wide range of environmental tests according to a number of different standards. In addition to testing of electronic components, we have a solid experience in testing composites and in accelerated corrosion testing.

## Temperature

- Tests according to:
  - RTCA DO-160, section 4 and 6
  - MIL-STD-810, method 501-5 and 502-5
  - IEC 68-2-2, IEC 68-2-3, IEC 68-2-30 and IEC 68-2-38
- Dimensions:
  - From 830 x 570 x 600 mm (w x d x h)
  - up to 2,000 x 3,000 x 2,000 mm (w x d x h)
- High/low-temperature tests:
  - Temperature range -80 to 180 °C
- Temperature Variation tests:
  - Maximum cooling rate of 10 °C/min
- Suitable for operational tests of electronic equipment
- Variety of Power supplies available
- Cable ducts with a diameter of 100 mm

## Humidity

- Tests according to:
  - RTCA DO-160, section 6
  - MIL-STD-810, method 507-5
  - IEC 68-2-2, IEC 68-2-3, IEC 68-2-30 and IEC 68-2-38
- Temperature range: -80 to 180 °C
- Relative humidity between 15% and 98%
- Proved seal methods for connectores and test cables

## Salt Spray

- Tests according to:
  - RTCA DO-160, section 14
  - MIL-STD-810 method 509.3
  - ASTM B117
  - ASTM G85 Annex A1, A2, A3 and A4 (Salt/SO<sub>2</sub>)
- Dimensions:
  - up to 1,100 x 800 x 600 mm (w x d x h)
- Standard and customized tests on avionics, coated and non-coated materials and structures.
- Temperature range between room temperature and +55 °C
- Solutions can be acidified
- Capable for tests with SO<sub>2</sub>
- Programmable spray, purge and soak periods



*Climate test chamber*



*Proved seal methods for connectores and test cables*



*Salt spray testing*



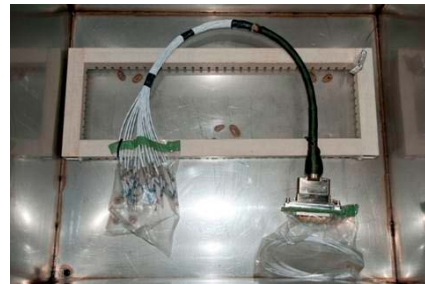


Rapid Decompression  
Facility (RDF)



## UV Light

- Tests according to:
  - ASTM D4329, D4587, D4799, D5208, G151, G154 (Cycle 1-6)
  - DIN EN 12224, 1297, 13523-10
  - DIN EN ISO 4892-1
  - ISO 11507 (Method A), 11997-2, 4892-3 (Cycle 1 and 6)
  - SAE J2020
- Fluorescent UV lamps:
  - UVB 313, UVA 340, UVA 351
- Specimen holder dimensions:
  - 3 x 6 inch
  - 4 x 6 inch
  - Other dimensions on request



*Cables inside fluid susceptibility cabinet*

## Fluids Susceptibility

- Tests according to:
  - RTCA DO-160, section 11
  - MIL-STD-810 method 504.1
- Spray and Immersion tests
- Dimensions contamination box:
  - Spray test: 750 x 700 x 500 mm (w x d x h)
  - Dimensions test box for Immersion test on request
- Fluid temperatures up to 80 °C (depending on flashpoint)
- Temperature controlled test box
- Programmable spray intervals
- Wide range of fluids available
- Contamination with paste-like substances possible



*iPad used as Electronic Flight Bag*

## Altitude Decompression & Overpressure

- Test according:
  - RTCA DO-160G section 4
  - MIL-STD-810G Procedure III
  - Customer specifications
- Test Article dimensions 700 x 700 x 700 mm
- Decompression: Max. operation altitude: 55,000 ft
- Minimal decompression time: 2 seconds
- Altitude: Maximum operation altitude: ~60,000 ft
- Vacuum feed troughs for: Power, thermocouples, data signals, cooling water, video and USB



*Icing test*

## Icing

- Tests according to:
  - RTCA DO-160, section 24, Category: C
  - RTCA DO-160, section 24, Category: B on agreement
- Executed with climate chamber and cooled spray bottle



*Continuous Stream Proof test*

## Waterproofness

- Tests according to:
  - RTCA DO-160, section 11, Category: Y, W, R and S
  - MIL-STD-810, method 504.1
- Test rigs available for:
  - Condensing Water Proof test
  - Drip Proof test
  - Spray Proof test
  - Continuous Stream Proof test
- Water temperature up to 50 °C



Thermal vacuum tests  
of the Mechanical  
Pumped Fluid Loop in  
the space simulator



# THERMAL VACUUM LABORATORY

Our Space department's Thermal Vacuum laboratory carries out research on aerospace-related thermal issues. The laboratory is equipped with various data acquisition /logging systems for different types of temperature and vacuum/pressure sensors, and 50 Hz infrared camera.

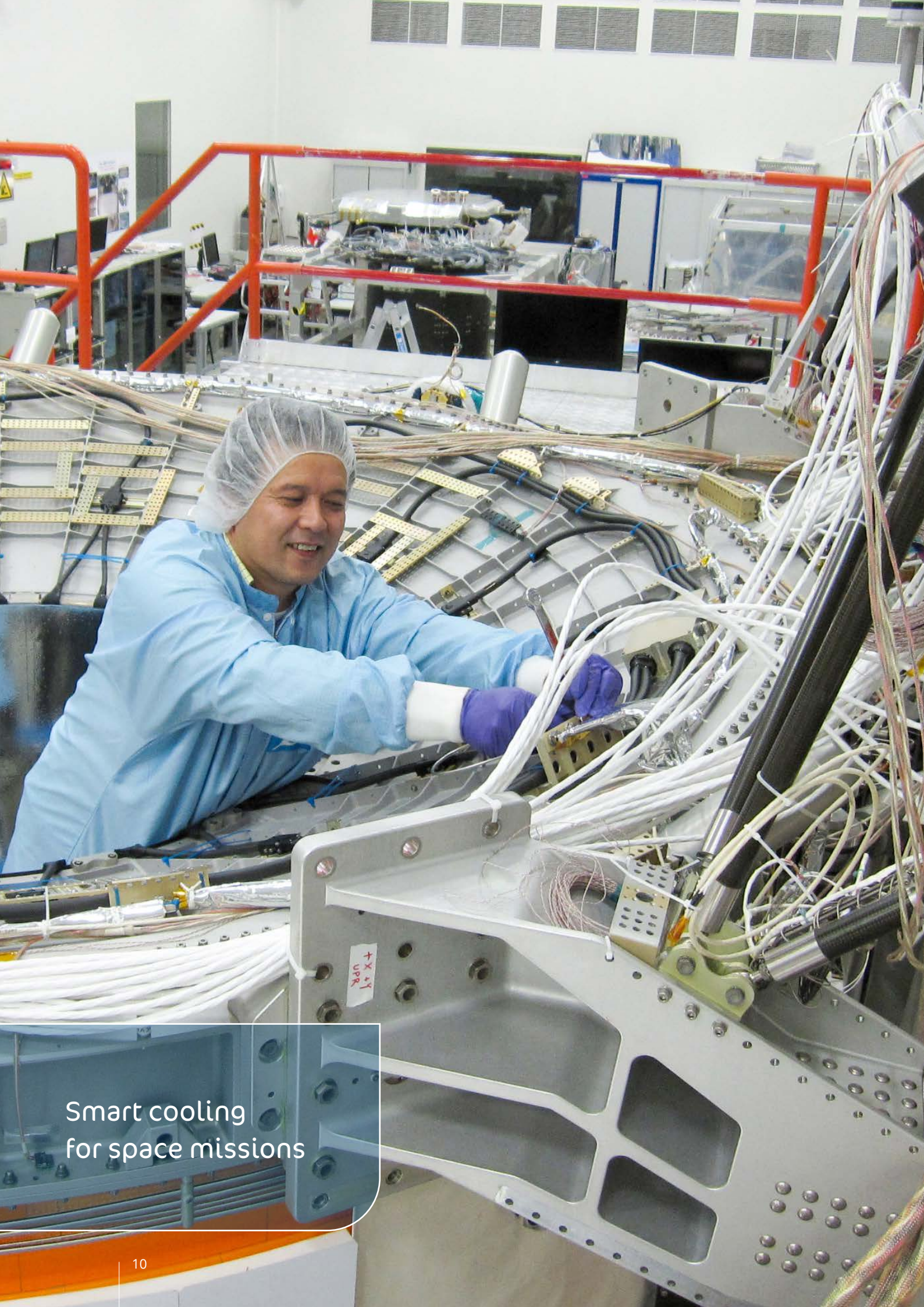
Furthermore, single-phase and two-phase liquid/vapor heat transport systems can be developed and tested. To this end, a range of Coriolis mass flow meters, pumps, tubing and fittings are available. Fluid properties such as contact angle, surface tension and density can be measured with dedicated equipment.

## Thermal Vacuum chamber (Space Simulator)

- Shroud temperature:
  - Range -150 to 150 °C
  - Max. rate of change:
    - 1.7 °C/min. upslope
    - 3.0 °C/min. downslope
  - Programmable temperature profiles
- Heat sink temperature (independent from shroud temperature):
  - Range -100 to 150 °C
  - Max. rate of change:
    - ≈7 °C/min. upslope
    - ≈10 °C/min. downslope (depending on test item and interface plate thermal masses)
  - Programmable temperature profiles
  - Small and large heat sinks
- Pressure:
  - Ultimate vacuum:  $<1 \times 10^{-5}$  Pa (depending on test item outgassing)
- As altitude chamber: 1-950 mbar (>100.000 ft, 32 km); temperature depending on pressure
- Mechanical dimensions:
  - Useful dimensions: 150 x 90 cm (length x diameter)
  - Various feed-through flanges from 2 x 4" to 2 x 11"
  - One viewing glass for visible and infrared light
- Data acquisition:
  - Independent data acquisition/logging system
- Dry vacuum pump system, with a cryogenic pump for high vacuum
- Quartz crystal microbalance for cleanliness monitoring of the chamber and test item







Smart cooling  
for space missions



### Climatic chamber

- Temperature:
  - Range -70 to 260 °C
  - Max. rate of change: 30 °C/min. (using nitrogen cooling)
  - Programmable temperature profiles
- Dimensions:
  - Useful dimensions: 109 x 99 x 112 cm (h x w x d)
  - Two generic feed-through holes of 15 cm diameter
  - Several grids for installation on different heights
- Data acquisition:
  - Fixed 5-channel Pt-100 data logging system, expandable with an independent data acquisition/logging system
- Three freely usable relay contacts for switching of electrical electronic equipment

### Clean room

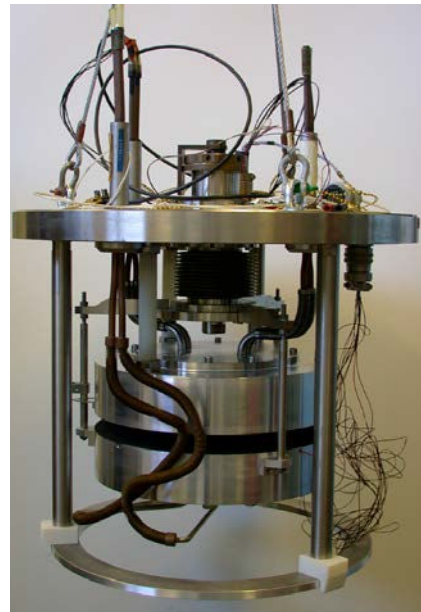
A clean room is available for installing test items in thermal (vacuum) equipment, or as a clean test environment.

- Classification: ISO Class 8 (Class 100,000)
- Dimensions: 4 × 3.5 × 3 m

### Thermal conductivity apparatus (ASTM C177)

This apparatus measures the rate of heat flow through a sample in vacuum, using the guarded hot-plate method. It can be used for testing of e.g. honeycomb panels.

- Vacuum level:
  - Down to  $1 \times 10^{-5}$  Pa
- Sample size:
  - Max. diameter 300 mm
  - Max. thickness 30 mm
- Temperature range:
  - Hot plate max. temperature 100 °C
  - Cold plate min. temperature -40 °C
- Thermal conductivity value:
  - 1.6 W/m·K typ.



*Thermal conductivity apparatus*





Vibration test of  
small satellite



# VIBRATION & SHOCK TEST LABORATORY

The NLR Avionics Division operates a laboratory for vibration and shock tests. These tests can be done in accordance with any applicable standard including the RTCA DO-160F, MIL-STD-810F and IEC standards. Also dedicated test procedures can be applied. The VST laboratory is included in the Dutch Accreditation Council (RvA) register of test laboratories under no. L220, for areas described in detail in the accreditation.

The VST-lab has three vibration test systems available:

Shaker system	TIRA	LDS	LDS
Type	50350	V810	V875LS
Head	115 mm	240 mm	440 mm
Sine force	2.7 kN	17.8 kN	35.6 kN
Random force	2.0 kN	13.3 kN	26.6 kN
Shock force	4.0 kN	34.8 kN	84.3 kN
Max. load	35 kg	249 kg	600 kg
Max. Displacement	1 inch	2 inch	2.75 inch
Max. Velocity	1.5 m/s	2.0 m/s	1.8 m/s
Max. Acceleration sine	125 g	120 g	112 g
Max. Acceleration random	75 grms	60 grms	56 grms
Armature resonance	> 3500 Hz	2500 Hz	2100 Hz
Control system/Data Acquisition System	LMS Mobile	LMS Scadas III	LMS Mobile
Max. channel count	8	16	16
Sliptable size	-	762x762 mm	750x750 mm
Head expander size	-	400x600 mm	762x762 mm

The two larger shakers (V810, V875) are used for general purpose vibration and shock tests, the smaller shaker is especially suited for small items that have to be tested for a high level/high frequency environment (e.g. turbojet engine components). A sine vibration level of 60 g for a 3 kg load is feasible up to 5 kHz.

## Combined testing and add-on equipment

- Removable clean room (guaranteed up to Class 100,000, FED-STD-209B/ ISO 14644-1 Class 8), with contamination monitoring equipment
- A temperature chamber which can be used in conjunction with the V810 shaker to create a temperature environment with the following characteristics:
  - Temperature range: -70 to 200 °C
  - Maximum rate of change: 30 °C/minute
  - Dimensions: 600 x 800 x 1,000 mm<sup>3</sup>
- A temperature controlled sliptable for thermal isolation
- Dactron photon+, 4-channel dynamic signal analyser
- A range of accelerometers: light (weight approx. 0.2 g), accurate, extreme temperature range, Tri-axial output
- Laser-based vibrometers for vibration measurements without mass loading (Ometron VH300, MicroEpsilon NCDT1700 laser displacement sensors)
- Mechanical workshop for quick mechanical repair and small modifications of test objects;
- (Clean room capable) Electronics workshop for immediate repair or modifications of test objects.



*TIRA vib SHAKER 50350*



*LDS V810 Shaker-sliptable combination*



*LDS V875 shaker-sliptable combination*





Test set up: antenna positioning at RNLAf KDC-10 transport aircraft



# EMC LABORATORY

The EMC Laboratory of the Avionics Technology department carries out testing and analysis concerning Electromagnetic Compatibility (EMC) and Electromagnetic Interference (EMI) of electrical and electronic equipment. Testing can be done in accordance with most applicable aerospace standards including EUROCAE ED-14 (RTCA DO-160), MIL-STD-461 and Boeing D6-16050 standards. Other standards (e.g. FCC, IEC, DEF-STAN) and dedicated test procedures can also be supported. The NLR EMC test laboratory is included in the Dutch Accreditation Council (RvA) register of test laboratories under no. L220, for areas described in detail in the accreditation.

The EMC laboratory is equipped with a semi anechoic shielded room (SAR) for EM emission measurements as well as EM susceptibility testing of equipment. The SAR is equipped with radio frequency energy absorbers, high performance filters for mains power (DC, 50 Hz, 360-800 Hz) as well as water supply and an exhaust extraction system.

Electromagnetic radiated susceptibility (EMS) tests can be performed with field strengths of at least 200 V/m in the frequency range 10 kHz up to 18 GHz, covering most of the military and civil equipment requirements with respect to High Intensity Radiated Fields (HIRF).

The EMC measurement equipment (including the high power amplifiers) are portable and transportable, enabling in-situ measurements at outdoor locations (e.g. inside aircraft/rotorcraft or at a manufacturer's premises).

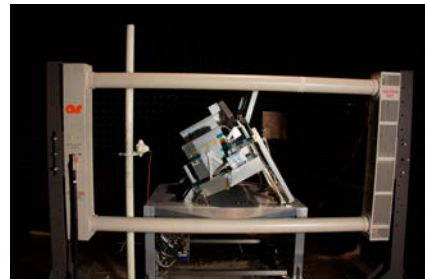
The EMC facility operates test equipment to perform Lightning Induced Transient Susceptibility tests according ED-14 / DO-160 section 22:

- Waveforms: 1, 2, 3, 4, 5A, 5B, 6
- Level 1 to 5
- Single Stroke, Multiple Stroke, Multiple Burst
- Pin Injection, Cable Induction, Ground Injection

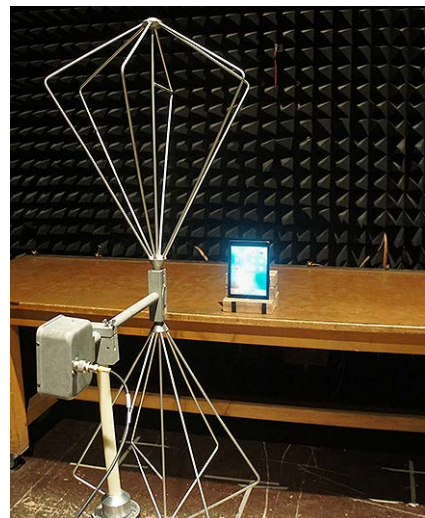
## Other capabilities of the NLR EMC facility are:

- In-situ EMI tests on customer specifications
- Helicopter platform annex Open Area Test Site (OATS) for emission measurements and antenna calibrations
- Variable frequency AC power source (9 kVA) for power quality tests
- Wiring and cable shielding measurements (crosstalk and transfer impedance)

In addition to measurements the EMC laboratory is also involved in modelling and analysis of the EMC characteristics of cables (crosstalk and transfer impedance) and is involved in the analysis of potential electromagnetic interference on aircraft and airports.



*Radiated susceptibility tests on space equipment*



## Plot

NLR is a founding Member of the Dutch Association for Environmental Technology (PLOT).





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of aerospace

**NLR'S CUTTING EDGE TECHNOLOGY FINDS  
ITS WAY TO AEROSPACE PROGRAMS IN  
CIVIL AND MILITARY SECTORS.**



**Requirements & Specification**



**Concept development**



**Design & Analysis**



**Prototyping & Manufacturing**



**Testing, Verification & Validation**



**Qualification & Certification**

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