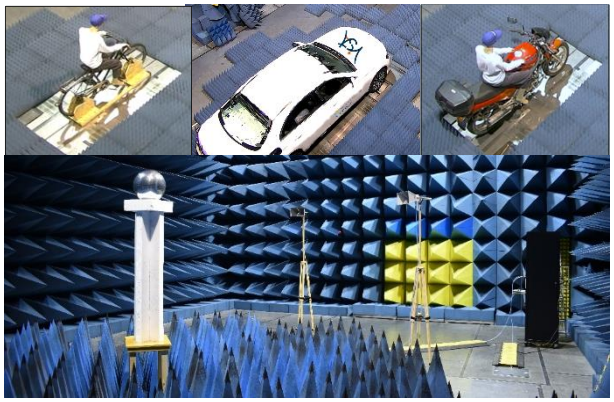
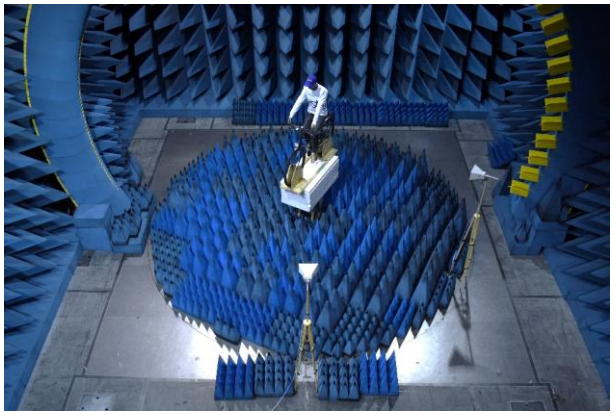
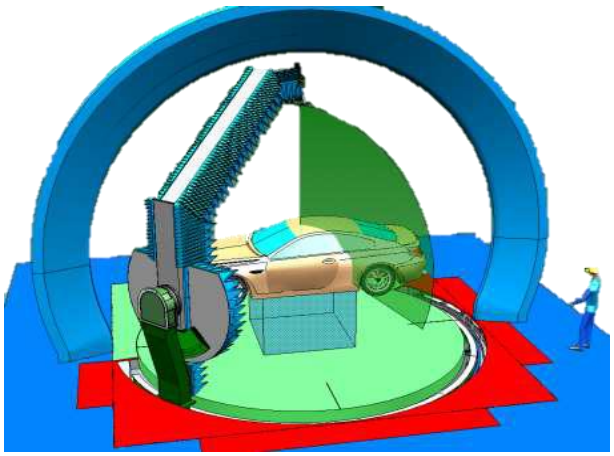
Antenna and RCS measurements (RF, microwave & millimetre wave)

- Monostatic and bi-static RCS measurements covering the frequency ranges 0.8...26.5 GHz and 67...115 GHz
- Measurements with variable illumination and observation angles (2D, 3D)
- Broadband dual-polarimetric measurement of different traffic-relevant radar objects (real size and scaled)
- Power calibration using certified reference objects
- Extensive digital signal post-processing

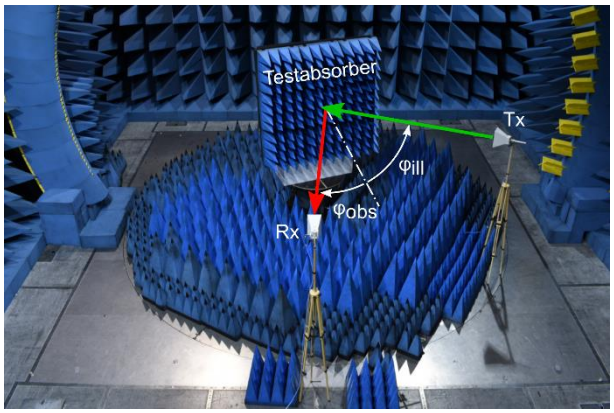






Modeling of electromagnetic microwave absorbers

- Broadband reflectivity measurements in the frequency range 0.8...18 GHz
- Automated monostatic and bi-static measurements at variable illumination / observation angles
- Characterisation of weakly reflecting microwave absorbers down to -60 dB
- Vertical test plane (1.80 m x 1.80 m) for evaluation of different absorber configurations
- Comparison with numerical simulations (full-wave simulations and ray tracing)



Testbed for system evaluation of automotive radar

- Manufacturer and platform independent over-the-air testing of automotive radar systems in VISTA
- Digital radar-target simulator

  Automotive radar test system for real-time and broadband simulation of Doppler shifts and radar cross sections

  Type: dSPACE DARTS-9030 M

  Frequency range: 75...82 GHz

  Chirp signal bandwidth: 1000 MHz

  Minimum distance: 7.5 m

  Maximum distance: 1000 m

  Number TX modules: 8

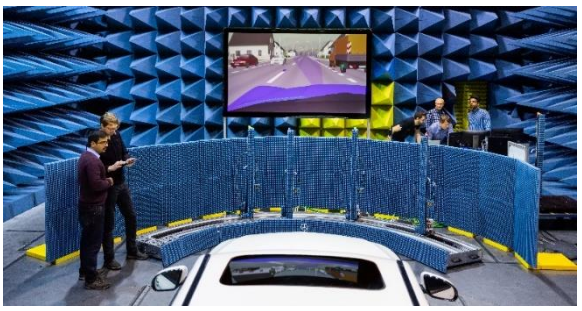
- Scenario-based camera stimulation

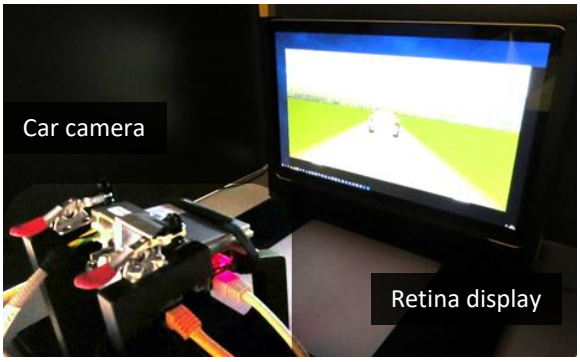
  Photo-realistic HiL tests of automotive camera

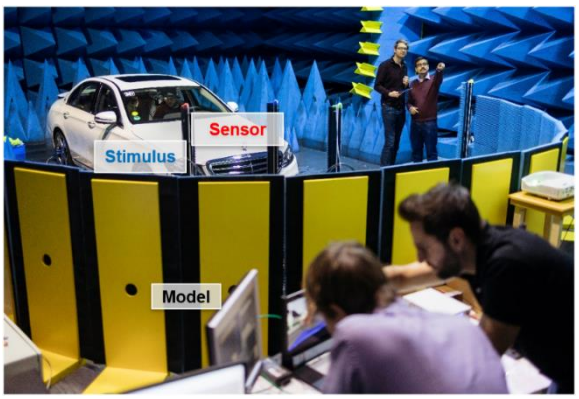
  Retina display (resolution 2560 x 1600; 227 dpi)

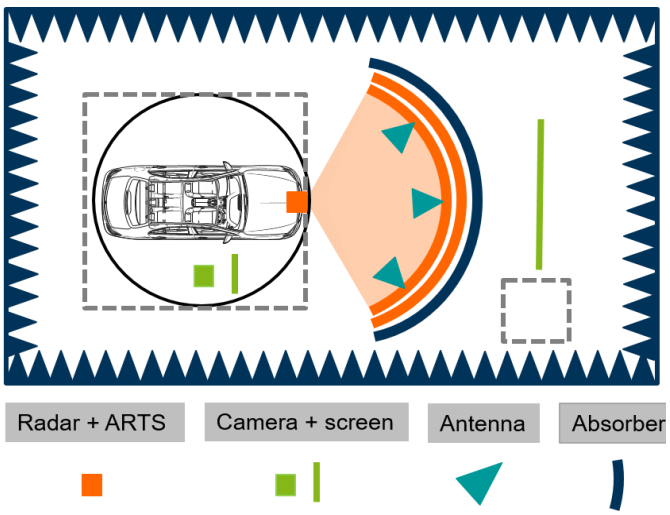
  Stand-alone operation or fusion with automotive radar

  External interface via CAN data bus
- Hardware-in-the-loop (HiL) test system Scalexio E31275 with ControlDesk, ConfigurationDesk, and AutomationDesk
- Spectral analysis up to 110 GHz including analysis of modulation contents up to 4 GHz bandwidth









Adaptable electromagnetic boundary conditions for antenna measurements

- Studies of the effect of electromagnetic boundary conditions on the radiation behaviour of automotive antennas
- Artificial ground plane for antennas
- Glass fibre-reinforced plastic frame :

  Diameter: 5.8 m

  Height adjustable: 0.7...2.3 m

- Fabric: Bottom layer of silver-plated nylon parachute silk with conductive PU coating (Shieldex® Berlin RF)

  Areal resistance: Average 300 mΩ/m² (max < 500 mΩ/m²)

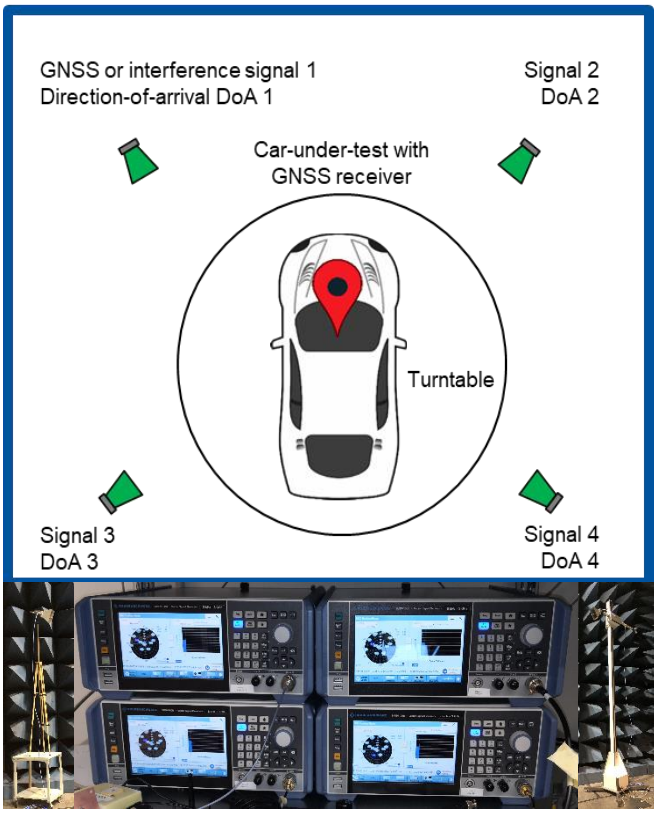
  Shielding effectiveness: Average up to > 60 dB in the frequency range 0.3...5 GHz

- Top layer of silver-plated nylon parachute silk with additional copper/nickel coating (Shieldex® Nora Dell CR)

  Areal resistance: Average 9 mΩ/m²

  Shielding effectiveness: Average up to 95 dB in the frequency range 0.3...10 GHz

Shielded anechoic chamber (VISTA)

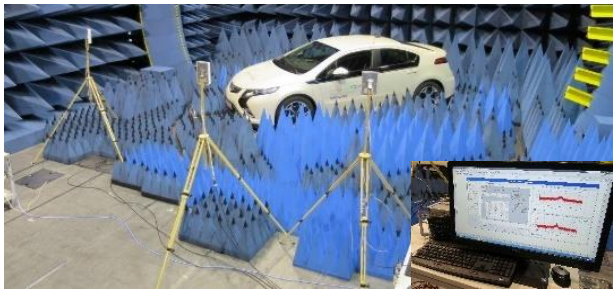


Emulation of satellite navigation

- GNNS satellite simulation with 4 synchronised Rohde & Schwarz signal generators Type: SMBV100B
- Illumination of the scenario from different directions (azimuth and elevation) to reproduce the real direction-of-arrival of the satellite signals
- Generation of defined noise and interference signals to evaluate the immunity of receivers
- Test of complete receivers in installed state
- Scenarios based on GPS and Galileo as well as combinations

Wireless channel emulation in VISTA

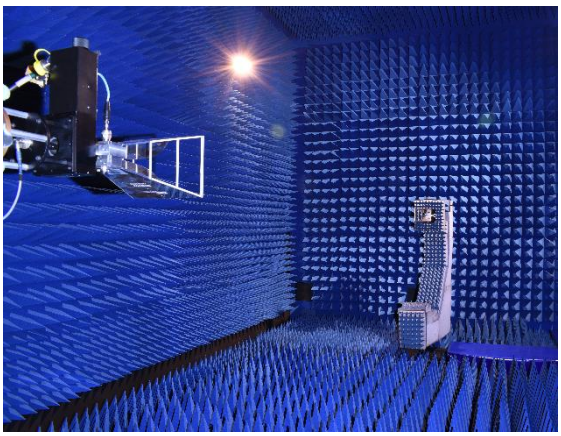
- Combined hardware- and software-based modeling of mobile services (LTE, 5G, DSRC, C-V2X) with over-the-air methods
- Emulation of ray clusters using sectorised antenna arrays
- MIMO functionality
- Adjustment of Doppler shifts, signal delays, and angular directions in terms of absolute values and spreads
- Measurement of relevant transmission parameters such as data throughput in uplink and downlink, RSRQ, RSRP, RSSI, CQI, and SINR
- Channel emulator: Keysight Propsim F32
  - 24 channels
  - Frequency range 0.35...6 GHz
  - Bandwidth 40 MHz
  - Channel modeling software for LTE-A and MANET scenarios
  - Emulation of shadowing (large-scale fading) from 0 to 100 dB in 0.01 dB steps
  - Remote configuration and control of emulations



Antenna measurement laboratory (complementary to VISTA)

Antenna characterisation through far-field measurements, optionally nearfield – far-field transformation if used as spherical nearfield scanner

Manufacturer:	Nearfield Systems, Inc.
System:	NSI-800F-10x with nearfield measurement option NSI-SW5305
Shielded room:	8.9 m x 5.1 m x 5.1 m
Frequency range:	0.8 … 110 GHz
Maximum load of positioner:	10 kg
Measurement distance:	5 m
Angular resolution:	0.03°



Fraunhofer IIS

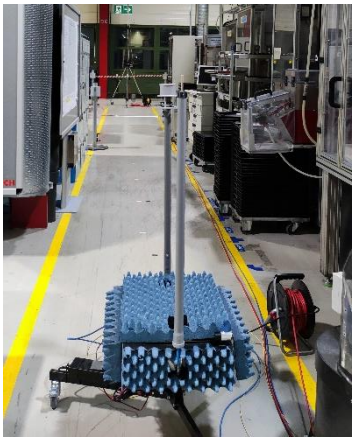
Channel Sounder

Sub 6 GHz Sounder

- Instrumentation: Hardware for polarimetric, double-directional, mobile channel measurements
- Specifications:
  - Antenna arrays for 2.53 GHz and 5.2 GHz
  - Approx. 100 MHz bandwidth [antenna arrays for 3.75 GHz currently planned]
  - Software-defined radio transceivers up to 6 GHz
- Picture on the right: - Antenna arrays for 2.53 GHz, implemented as stacked polarimetric uniform circular patch array (SPUCPA) with high-frequency switches in the chassis.

mm-wave to THz measurement and sounder technologies

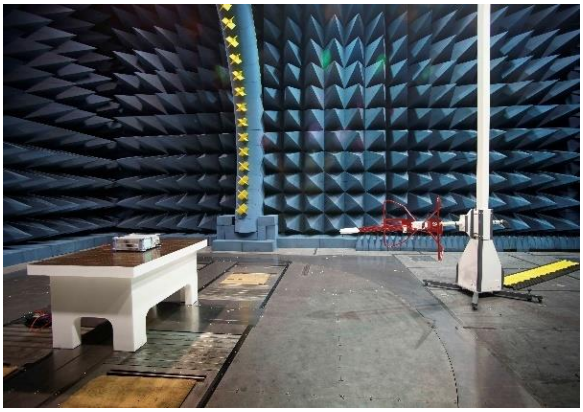
- Instrumentation:
  1. non-linear HF characterization with PNAX up to 67GHz
  2. Network measurement technology up to 340 GHz
  3. Broadband technology up to 16 GHz bandwith (AWG7000 and DPO70000)
  4. Multi band UWB channel sounder up to 300 GHz
- Specifications of UWB channel sounder:
  1. ≤ 7 GHz bandwith
  2. Up to 2h realtime data storing with 4 channels
  3. Multi-band operations up to 3 frequency bands in parallel
     - Microwave range: 0...3.5 GHz / 3.5...10 GHz
     - mm-wave range: 24...40 GHz / 57...66 GHz / 71...78 GHz
     - THz range: 180...220 GHz/ 280...340 GHz
  4. Measurement of 5G and 6G radio channels
- Tests:
  - Channel Sounding, BS-UE, AP-UE, D2D, incl. V2X
  - Spatial-temporal characterization of radio channels
  - Test of 5G and 6G technologies



EMC measurements

Pre-compliance EMC measurements of radiated and conducted emissions in VISTA

EMC chamber:	Shielded semi-anechoic chamber, 16 m x 12 m x 9 m
Antenna mast:	Measurement heights 1 … 4 m
Instruments:	EMI test receiver, Rohde & Schwarz ESR-7, Artificial mains network Rohde & Schwarz ENV432
Frequency range:	9 kHz … 6 GHz
Measurement distance:	3… 5 m

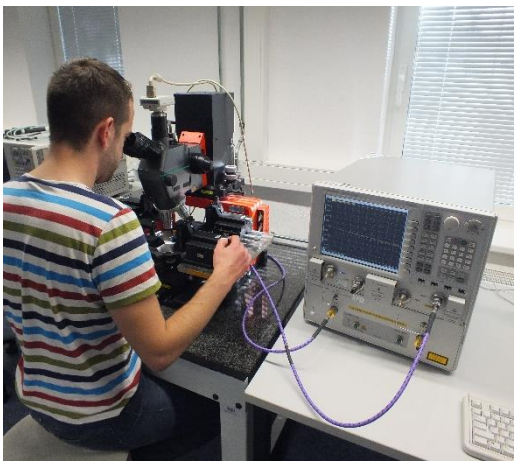


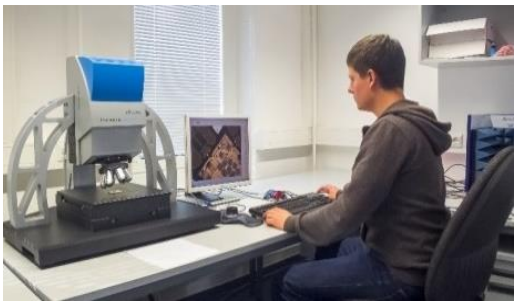
Human exposure (RF und ELF)

Instrumentation:	Handheld selective radiation meter Narda SRM-3006
Frequency range:	9 kHz to 6 GHz
Antenna:	Triaxial E-field antenna 0.027… 3.0 GHz 0.42 … 6.0 GHz
Special feature:	code-selective UMTS and LTE measurements
Tests:	Field measurements of electric field strengths for different radio services in terms of human exposure in RF electromagnetic fields
Instrument:	Combined E- and H- field analyser Narda EHP-50F
Frequency range:	1 Hz to 400 kHz
Special feature:	Weighted peak assessment, FFT spectral analysis
Tests:	Field measurements of ELF electric and magnetic fields, e.g., at electrical power supply sites (overhead lines, transformer stations)

Microwave measurements (Frequency domain and time domain)

- Coaxial vector network analysers:
  - Agilent PNA-X N5242, 4-port test set,
  - Nonlinear X-parameters 0.01...26.5 GHz
  - Light-wave component analyser Agilent N4376D,
  - Agilent PNA E8361A: 0.01...67 GHz,
  - Keysight PNA N5222B: 0.01...26.5 GHz und 67...115 GHz
  - 4-port test set 0.01...50 GHz,
  - Pulse test set 0.2...40 GHz;
  - Anritsu MS4630B (10 Hz bis 300 MHz)
  - Keysight FieldFox N9952A - Microwave Analyser up to 50 GHz
- Maury tuner-based noise parameter measurement 1...26,5 GHz
- Noise factor analyser 0.01...26.5 GHz (Agilent N8975A)
- Spectrum analyzers
  - 50 GHz und 75...110 GHz (Agilent PSA E4448A, ext. Mixer)
  - 26 GHz (Rohde & Schwarz FSEM)
  - 32 GHz (Anritsu MS2802A)
  - 50 GHz (Keysight FieldFox N9952A)
- Wafer probing stations:
  - Suess PM4
  - Cascade Summit 9000
  - Vacuum wafer prober Suess MicroTec PMV150 with Thermochuck (-40 bis 150oC)
- Time-domain reflectometer (LeCroy SDA100G)
- Transient analysis (HP 70820A)
- 4-GHz four-channel real-time oscilloscope (Keysight DSOS404A with Smart Mixer 60...90 GHz)
- 11-GHz four-channel real-time oscilloscope (LeCroy SDA 11000)
- 20 GHz Agilent Infiniium DCA-X 86100D oscilloscope with optical inputs 750...1650 nm
- 70-GHz sampling oscilloscope (LeCroy SDA 100G)
- Signal Source Analyser 26.5 GHz (Rohde & Schwarz FSUP)
- Signal sources: e.g. Agilent PSG E8257D up to 50 GHz ; SMIQ06B up to 6 GHz; Vector Signal Generator R&S SMBV100B (GPS, Galileo)
- Optical profilometer "Alicona infinite focus" (resolution: vertical 20 nm, horizontal 600 nm)
- PCB prototyping with LPKF ProtoMat S103
- Nearfield antenna measurement system EMSCAN RFxpert RFX2-62 for fast measurement of radiation properties of planar structures 0.3...6 GHz
- Compute server Windows- and Linux-based
- Simulation tools for RF circuit design: MicroSim (PSpice), Serenade
- Simulation tools for 2D/3D microwave field calculations: Keysight ADS, Ensemble (MoM), IE3D (MoM), Ansoft HFSS (FEM), CST Microwave Studio (FDTD) including current desktop computing technology
- Data processing: MatLab with SimuLink Toolboxes (The Mathworks)



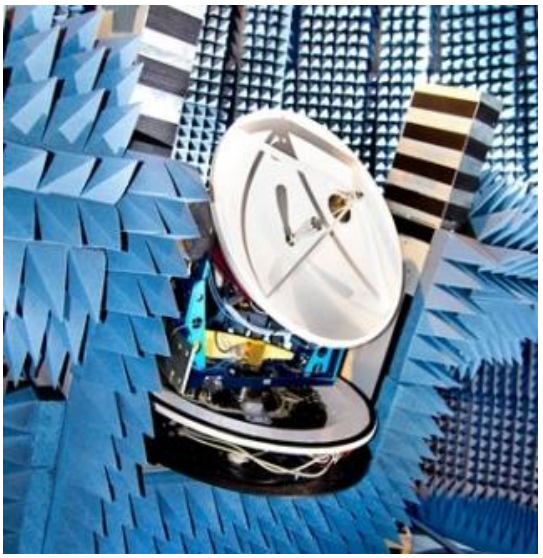


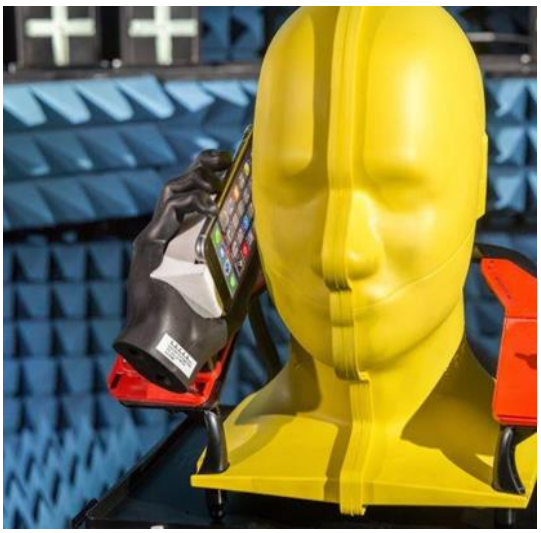
Fraunhofer IIS

FORTE test facility of Fraunhofer IIS (Facility for over-the-air research and testing)

- Measurement platform for mobile satellite terminals in the Ku and Ka bands with motion and channel emulators
- Measurements of 5G phased-array antennas in frequency range FR2 (> 6 GHz)
- Over-the-air test environment for communication and navigation systems (GNSS) up to 6 GHz
- Emulation of realistic, three-dimensional and virtual electromagnetic environments using wavefield synthesis (WFS) for electrically small test objects, and wireless cable for electrically large test objects

Detailed information at:
https://www.iis.fraunhofer.de/en/ff/kom/satkom/forte_satcom.html





In cooperation with Fraunhofer Institute for Integrated Circuits IIS:

Contact Person:

Dr.-Ing. Markus Landmann

markus.landmann@iis.fraunhofer.de

Fraunhofer IIS

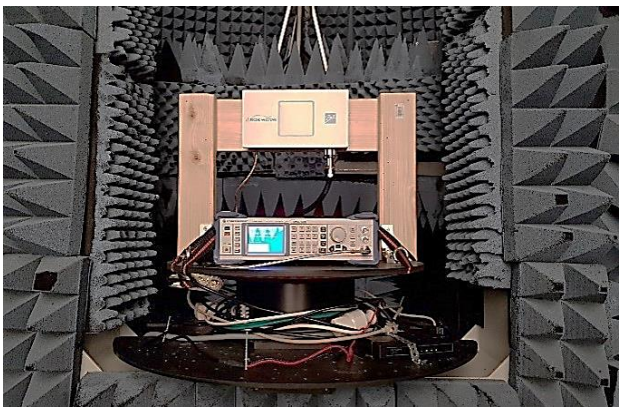
FORTE test facility of Fraunhofer IIS (Facility for over-the-air research and testing)

Research platform SatCom

- Testing of SatCom-on-the-move (SOTM) terminals for:
  - Global VSAT Forum SOMAP type approvals
  - Terminal manufacturers and satellite operators
- Competences:
  - Synchronised playback of realistic profiles via satellite, motion, channel and GPS emulators
  - Tests with standard motion profiles for land-mobile and maritime applications
  - Motion Emulator: Angle (roll, pitch, yaw): up to ±45o / continuously
Rate: 300o/s
Acceleration: 1000o/s²
  - Satellite Payload: 50 m antenna tower for satellite payload emulation with 80 MHz bandwidth
  - Channel Emulator: Realistic C/N and realistic shadowing profiles
  - Sensor array on the antenna tower for precise estimation of antenna de-pointing and adjacent-satellite interference (ASI)

Research platform 5G-mmWave

- Testing of 5G beamforming antennas in frequency range FR2
  - Platform development in the context of national funded projects
  - Projects with industry e.g. Anokiwave, Alcan, Kymeta
- Competences:
  - Measurement of antenna characteristics in far-field: Antenna pattern, gain, HPBW and SLL
  - Measurement of beamforming and null-steering capabilities

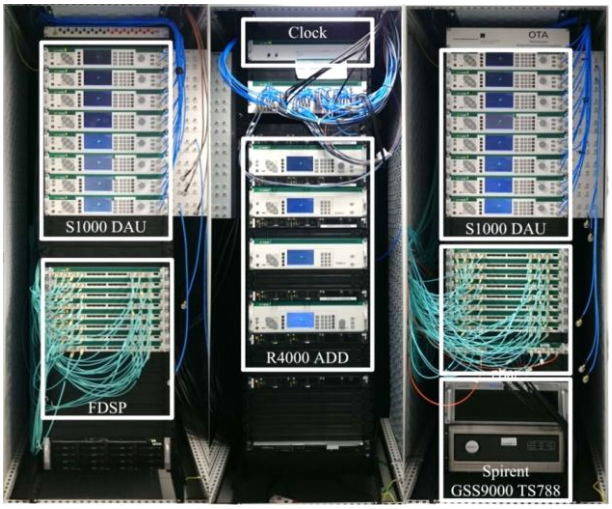


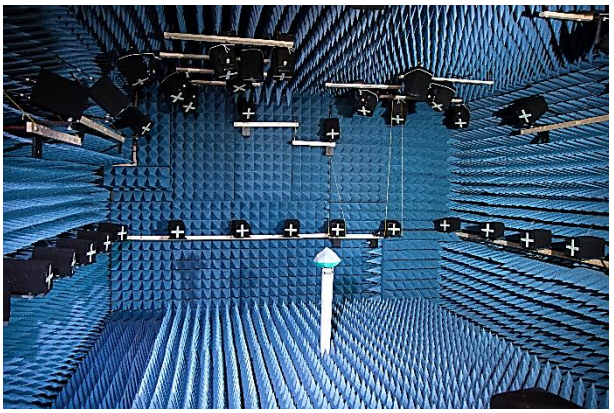
Fraunhofer IIS

FORTE test facility of Fraunhofer IIS (Facility for over-the-air research and testing)

Research platform MIMO-OTA

- Testing of MIMO transceivers up to 6 GHz for:
  - Mobile broadband (incl. LTE testbed, 5G)
  - GNSS positioning accuracy, interference immunity etc.
  - Industrial communication
  - V2V and V2I
- Signal generation
  - GNSS emulator Spirent GNS9000
  - Mobile communications: Rohde & Schwarz CMW 500
- Approaches
  - Wavefield synthesis for electrically small test objects
  - Wireless cable for electrically large test objects (e.g. vehicles)
- Channel modelling
  - (Geometry-based) stochastic channel models (e.g. 3GPP TS 38.901)
  - Ray tracing
  - Measured channels
  - Technical parameters
  - Frequency range: 0.3...6 GHz
  - Bandwidth: 80 MHz
  - RF Output: + 10 dBm
  - Connectivity: 12 Inputs x 32 Outputs = 384 Channels
  - 3072 taps / Impulse response





Detailed Information at: https://www.iis.fraunhofer.de/de/profil/standorte/forte.html