

KEY DIFFERENCES/SIMILARITIES IN RADIATED FULL VEHICLE EMC TESTING FOR AUTOMOTIVE AND MIL-STD

Christian Reimer
Regional Manager Testing Inspection Certification
Rohde & Schwarz International GmbH

PeO Karlsson
EMC Solution Specialist / EMC Application Engineer
Rohde & Schwarz

ROHDE & SCHWARZ

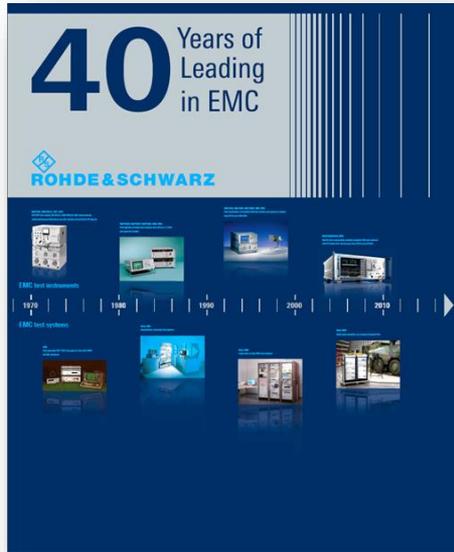
Make ideas real



AGENDA

- EMC at Rohde & Schwarz
 - EMC testing sectors
 - Scalability
 - Why EMC testing
- Key differences/similarities, in radiated full vehicle EMC testing for Automotive and MIL-STD
 - EMS (Radiated)
 - EMI (Radiated)
- Extension discussions ahead

EMC AT ROHDE & SCHWARZ



- EMC is core competence of Rohde & Schwarz
- In-house development of core EMC equipment and software
- Solution partner with far more than 1500 EMC turnkey test solutions realized worldwide
- Active participation in relevant standardization committees



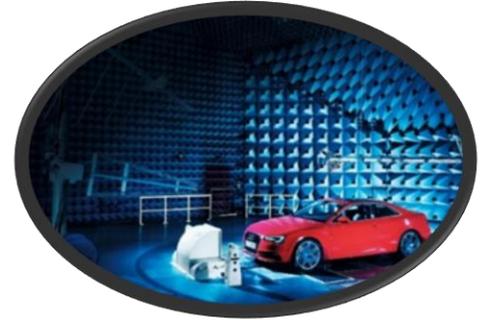
Aerospace & Defense



Commercial



Wireless



Automotive

SCALABILITY OF OUR EMC TEST SYSTEMS

EMC

electromagnetic compatibility

EMI
Electromagnetic
Interference

Conducted EMI | CE
Radiated EMI | RE



EMS
Electromagnetic
Susceptibility

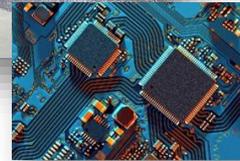
Conducted EMS | CS
Radiated EMS | RS





Courtesy to Halmstad University

WHY EMC TESTING



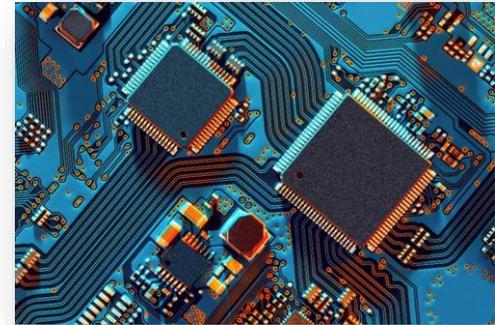
WHY EMC TESTING



ESU VHF/UHF
frequency range from 25 MHz to 900 MHz



ESW 44
frequency range from 1 Hz to 44 GHz



Time line



What are the challenges?
Aerospace & Defense



Commercial

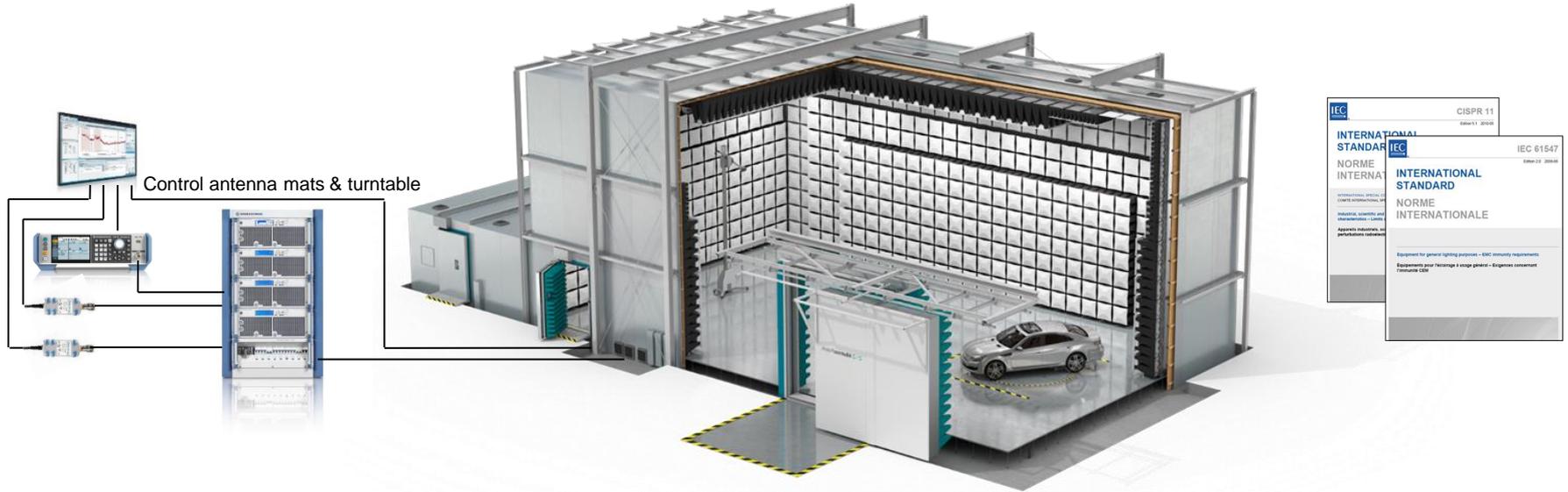


Wireless



Automotive

RADIATED EMS



EMS FULL VEHICLE TESTING

Standard	MIL-STD 461G RS103	ISO11451-2 + typ. OEM
Application	A&D components, applied also to vehicles	Commercial vehicles
Remark	Tailoring possible	Tailored by manufacturer standards
Frequency range	2 MHz to 18 GHz	20 MHz to 6 GHz (7.xyz GHz in future?)
Test distance	≥ 1 meter	≥ 2 meter
Field strength	50 V/m (Army Ground), up to 200 V/m others	typ. 100V/m manufacturer dependent (50 to 140 V/m)
Filed probe	1 probe, more allowed (see appendix RS103)	4 vertical field probes up to 2 GHz, 1 probe above Check of homogeneity
levelling	During test by field probe	Pre-calibrated

EMS FULL VEHICLE TESTING

Common components:

- Chamber
- High power amplifiers up to 6 GHz
- Antennas: vehicle stripline, Bicon or low-frequency LPD, LPD array, horn
- Field probes
- Test SW ELEKTRA
- Signal generators, power sensors, high-power cabling and switching
- ...

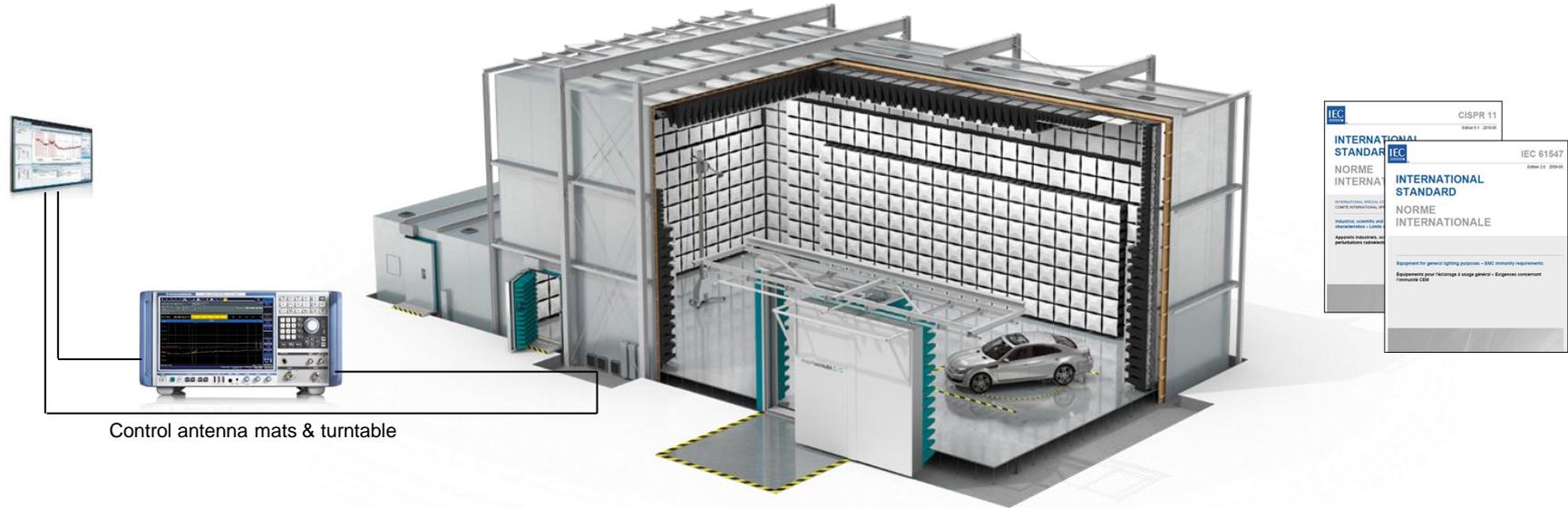


EMS FULL VEHICLE TESTING

Differences	MIL-STD 461G RS103	ISO11451-2 + typ. OEM
Chamber	Turn table optional No roller bench	Turn table recommended Roller bench
Test system	up to 18 GHz (40 GHz)	up to 6 GHz (7.xyz GHz in future?)
Amplifier power	must meet combined system requirements	
Field probe system	Typ. 1 probe	Typ. 4 probes

- Automotive and A&D requirements for full vehicle test can be combined in one system.
- The main components cover both.

RADIATED EMI



EMI FULL VEHICLE TESTING

Standard	MIL STD 461G RE102	CISPR12 / CISPR36
Application	A&D components, applied also to vehicles	Commercial vehicles
Frequency range	10 kHz to 18 GHz	9 kHz to 6 GHz (7.xyz GHz in future?)
Measurement device	EMC test receiver	
Antennas	Rod, Bicon, Horn	Rod, Loop, BiLog
Test distance	1m (minimum)	10 m

EMI FULL VEHICLE TESTING

Common components:

- Chamber
- FFT receiver is applicable for both, ESW44
- Antennas: Rod, Bicon or low-frequency LPD, horn,...
- Test SW ELEKTRA



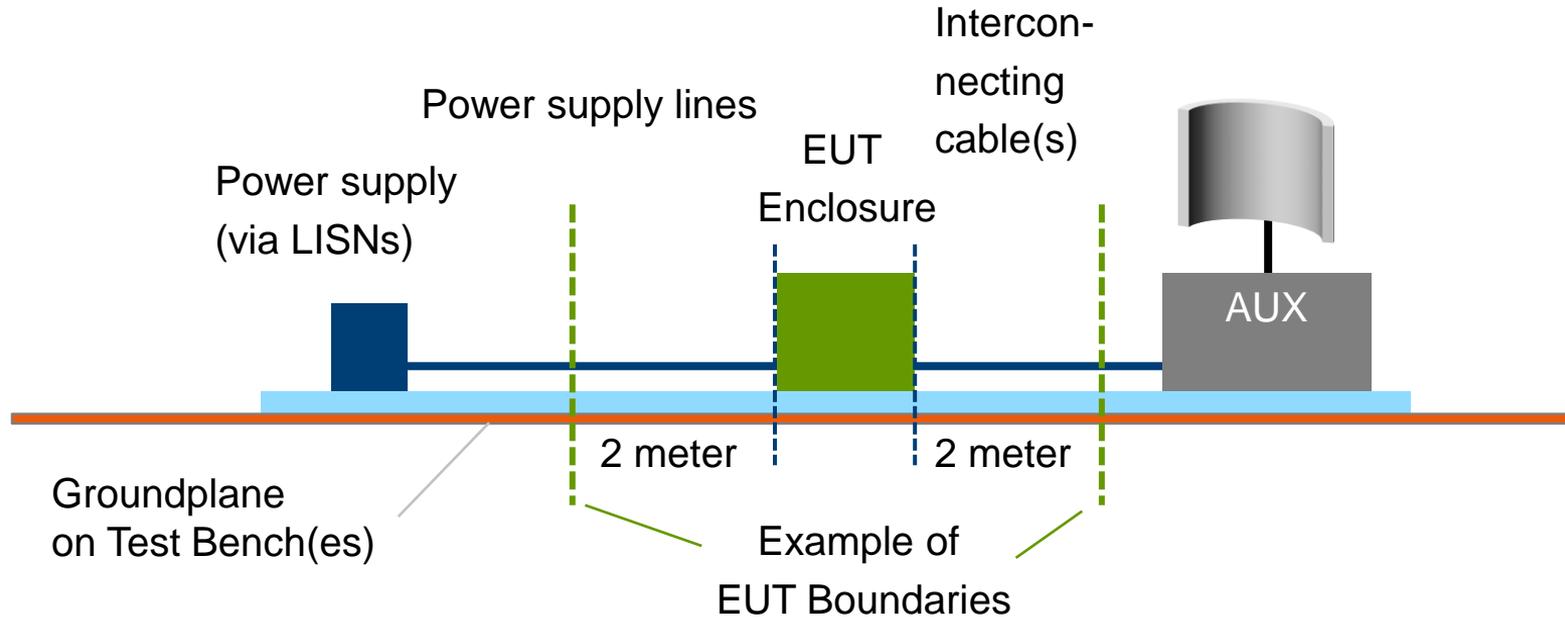
EMI FULL VEHICLE TESTING

Differences	MIL STD 461G RE102	CISPR12 / CISPR36
Chamber	Turn table optional No roller bench	Turn table recommended Roller bench
Test system	up to 18 GHz	up to 6 GHz (7.xyz GHz in future?)

- Automotive and A&D requirements for full vehicle test can be combined in one system.
- The main components cover both.

EXTENSION DISCUSSIONS AHEAD

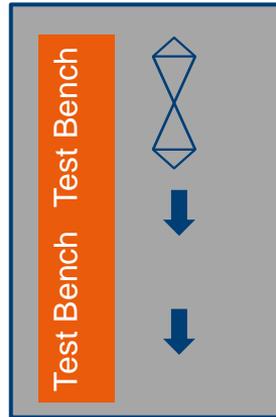
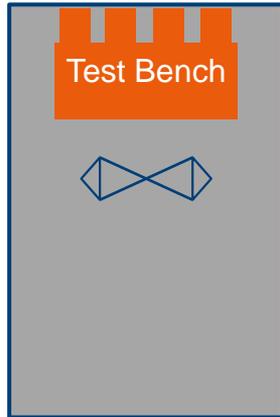
LARGER EUT SETUPS CALL FOR FLEXIBILITY



LARGER EUTS CALL FOR TEST SETUP FLEXIBILITY

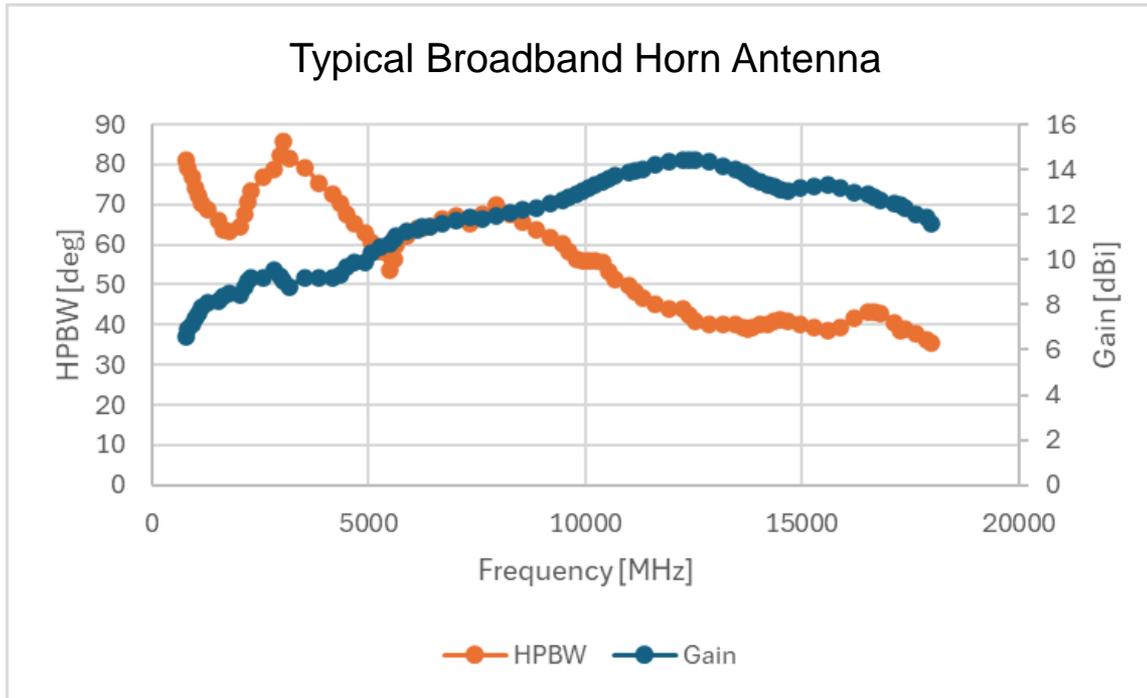
- ▶ Setup of EUT + cable arrangement can vary in size
 - Power lines → EUT enclosure → interconnecting cables → auxiliary equipment

Flexible Handling of Test Setups

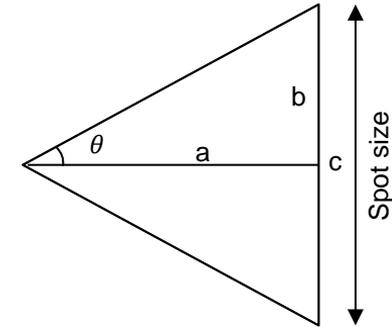


Several antenna positions needed
to cover the EUT including EUT boundaries
step by step

CONSIDERATIONS TO TAKE IN COUNT



Large EUT setups,
narrow beams at 1 m distance
→ different antenna positions
→ repetitive immunity tests



$\theta = 1/2$ antenna beam width (as specified by antenna manufacturer).

a = distance to setup boundary

$b = \tan(\theta) * a$

$c = 2 * b$ total antenna coverage (spot size)

OVERVIEW: APPLICABILITY

► The Standard is applicable for subsystems and equipment of:

LAND



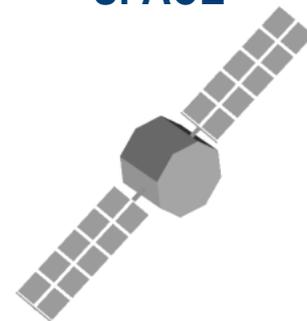
AIR



SEA



SPACE



OVERVIEW: REQUIREMENT MATRIX

Equipment and Subsystems Installed In, On, or Launched From the Following Platforms or Installations	Requirement Applicability																		
	CE101	CE102	CE106	CS101	CS103	CS104	CS105	CS109	CS114	CS115	CS116	CS117	CS118	RE101	RE102	RE103	RS101	RS103	RS105
Surface Ships	A	A	L	A	S	L	S	L	A	S	A	L	S	A	A	L	L	A	L
Submarines	A	A	L	A	S	L	S	L	A	S	L	S	S	A	A	L	L	A	L
Aircraft, Army, Including Flight Line	A	A	L	A	S	S	S		A	A	A	L	A	A	A	L	A	A	L
Aircraft, Navy	L	A	L	A	S	S	S		A	A	A	L	A	L	A	L	L	A	L
Aircraft, Air Force		A	L	A	S	S	S		A	A	A	L	A		A	L		A	
Space Systems, Including Launch Vehicles		A	L	A	S	S	S		A	A	A	L			A	L		A	
Ground, Army		A	L	A	S	S	S		A	A	A	S	A		A	L	L	A	
Ground, Navy		A	L	A	S	S	S		A	A	A	S	A		A	L	A	A	L
Ground, Air Force		A	L	A	S	S	S		A	A	A		A		A	L		A	

A: Applicable

L: Limited as specified
in the individual
sections of this
standard

S: Procuring activity
must specify in
procurement
documentation

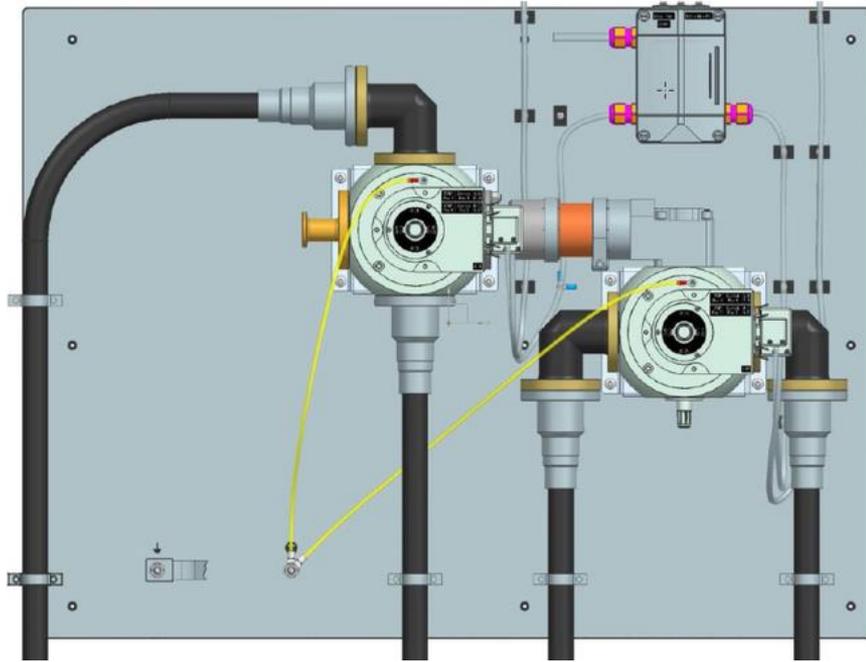
BROADCAST TRANSMITTER HISTORY SINCE 1949



RF SIGNAL ROUTING FOR HIGH POWER

e.g. 2x amplifier outputs routed to 2 chambers

Mechanical installation work onsite required



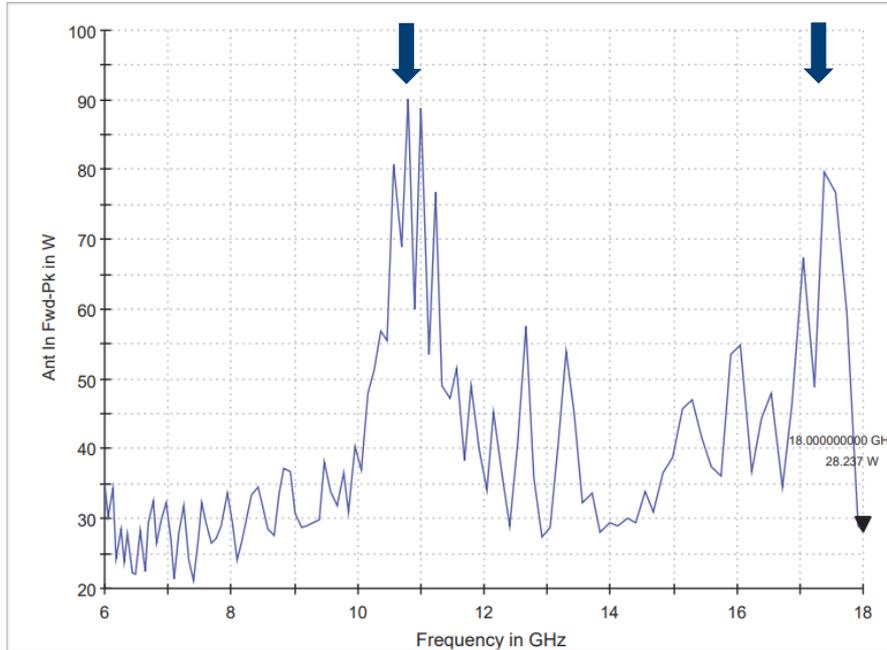
1 5/8" coax lines → more than 4 cm in diameter



Watch out:
RF power handling capability can
be VSWR dependent

KEY-CHALLENGES - RESONANCES

Antenna Input Power. RF path loss between amplifier and antenna to be regarded!



Power at Antenna →
Power at amplifier output higher

Fieldstrength as guide line
→ R&S to specify amplifier power!

Resonance* situation to be discussed
individually (where applicable)
Attention:

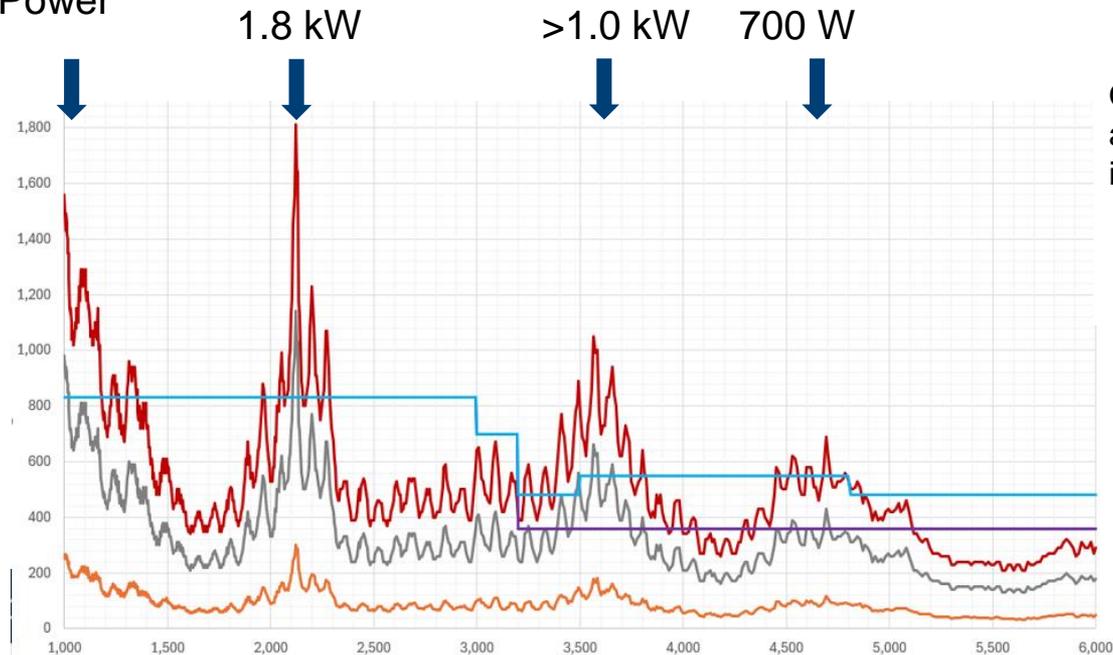
*Resonances translate into high power
requirements.

Mitigation efforts to be discussed.

200 V/m have been required. This graph has been put on the table for discussion.

KEY-CHALLENGES - RESONANCES

Power



Frequency range 1 GHz to 6 GHz

Overlay of amplifier power capabilities and actual power requirements for 200 V/m in an existing absorber chamber.

- 800 W + 550 W amp config
- 800 W + 400 W amp config
- Required Amp. Output power
- Theoret. Power at antenna
- Old situation 50 V/m

EXTENSION OF IMMUNITY TEST CAPABILITIES

- ▶ Focus on dedicated frequency ranges
 - e.g. typical frequency range extension from 6 GHz to 18 GHz
- ▶ Typical fieldstrength increases up to 50 V/m and 200 V/m
- ▶ Work split between manufacturer and outsourcing partner
- ▶ Complex test setups with complex EUTs can mean days (week) of preparation time and chamber occupation
 - Manufacturers need outsourcing partners
 - Parallel projects challenge organization of test chamber availability
 - Evaluation of EUT behavior can be difficult and time consuming
- ▶ Specialization on specific test cases
 - e.g. intermodulation tests
 - Testing in the low frequency range
 - Country-specific tests (typical topic for NATO members)

NATO: MIL-STD-461G OFTEN APPLIED AS REFERENCE

AECTP Requirement (Selection)

NCS12	Conducted Susceptibility, Electrostatic Discharge	Q
NCS13	Conducted Susceptibility, Transient Power Leads	V
NCS14	Conducted Susceptibility, Lightning Induced Transients, Cables and Power Leads	V
NRE01	Radiated Emissions, Magnetic Field	V
NRE02	Radiated Emissions, Electric Field	V
NRE03	Radiated Emissions, Antenna Spurious and Harmonic Outputs	V
NRE05	Radiated Emissions, Magnetic Field	FF, GG
NRS01	Radiated Susceptibility, Magnetic Field	V
NRS02	Radiated Susceptibility, Electric Field	V, Q
NRS03	Radiated Susceptibility, Transient Electromagnetic Field	V
NRS04	Radiated Susceptibility, Magnetic Field, (DC)	Q
NRS05	Radiated Susceptibility, Magnetic Field	HH, II

NATO: MIL-STD-461G OFTEN APPLIED AS REFERENCE

For R&S sales approach: country-related standards need individual discussions and cross-checks together with the customer

References (Selection)

FF.	VG 95373-22	Radiated emissions in the frequency range of 10 kHz to 30 MHz, Limits SA 02 G	
GG.	VG 95373-12	Radiated emissions in the frequency range of 10 kHz to 30 MHz, Test procedure SA 02 G	
Q.	DEF-STAN 59-411	Electromagnetic Compatibility	
	V.	MIL-STD-461G	Requirements for the Control of Electromagnetic Interference Characteristics of Subsystems and Equipment
HH.	VG 95373-23	Radiated susceptibility in the frequency range of 10 kHz to 30 MHz (magnetic field), Limits SF 02 G	
II.	VG 95373-13	Radiated susceptibility in the frequency range of 10 kHz to 30 MHz (magnetic field), Test procedure SF 02 G	

THE END - QUESTIONS



CONTACT

CONTACT DETAILS

Rohde & Schwarz customer support

www.rohde-schwarz.com/support



Rohde & Schwarz training

www.training.rohde-schwarz.com

Rohde & Schwarz International GmbH

Christian Reimer

Muehldorfstr. 15

81671 Munich

Germany

christian.reimer@rohde-schwarz.com

Office: +49 89 4129 13921

Mobile: +49 171 87 94 436

www.rohde-schwarz.com



CONTACT DETAILS

Rohde & Schwarz customer support

www.rohde-schwarz.com/support



Rohde & Schwarz training

www.training.rohde-schwarz.com

Rohde & Schwarz Sweden AB

PeO Karlsson

Flygfältsgatan 15, 128 30 Stockholm
Sweden

Per-olof.karlsson@rohde-schwarz.com

Office: +46 86051900

Mobile: +46 (0)702 83 76 29

www.rohde-schwarz.com

