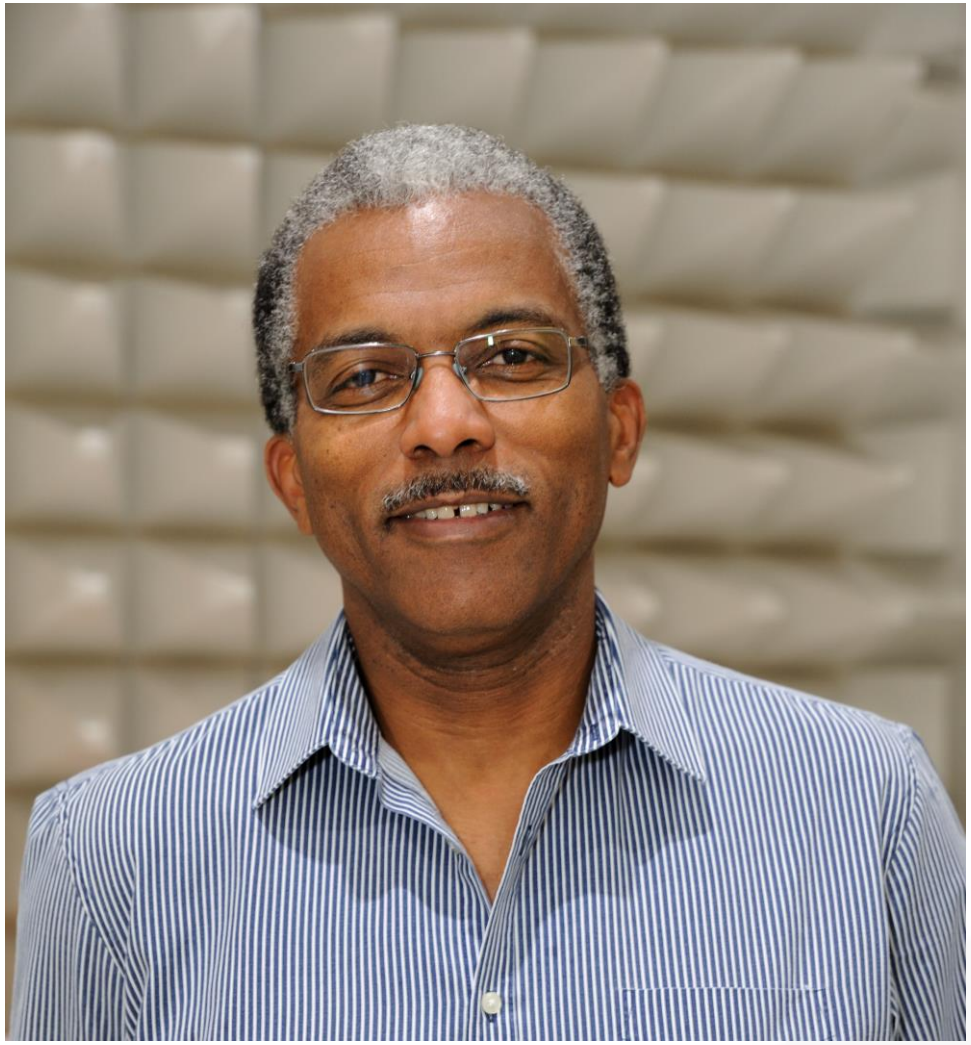
Garth D’Abreu

Garth D’Abreu is the Director, Automotive Solutions at ETS-Lindgren based at the corporate headquarters office in Cedar Park, Texas. He currently has primary responsibility for the design and development functions within the Systems Engineering group, specializing in turn-key solutions for Automotive EMC, Wireless and OTA test integration. Mr. D’Abreu is a senior member of the IEEE EMC Society, IEEE 2021 distinguished lecturer and active participant in standards development, including the SAE, ISO and CISPR D automotive EMC standards, with over 30 years of experience in the RF industry. He holds a BSc degree in Electronics & Communications Engineering, from North London University, UK.



What's new with EMC Tests for Vehicles

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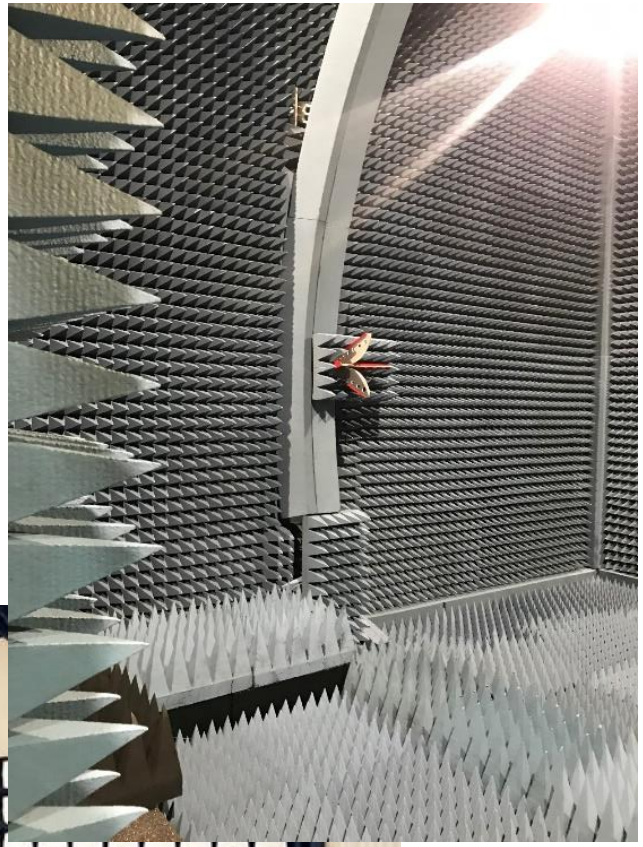
Outline

- Introduction
- Chamber design
- Test sites for Vehicle EMC
- Summary

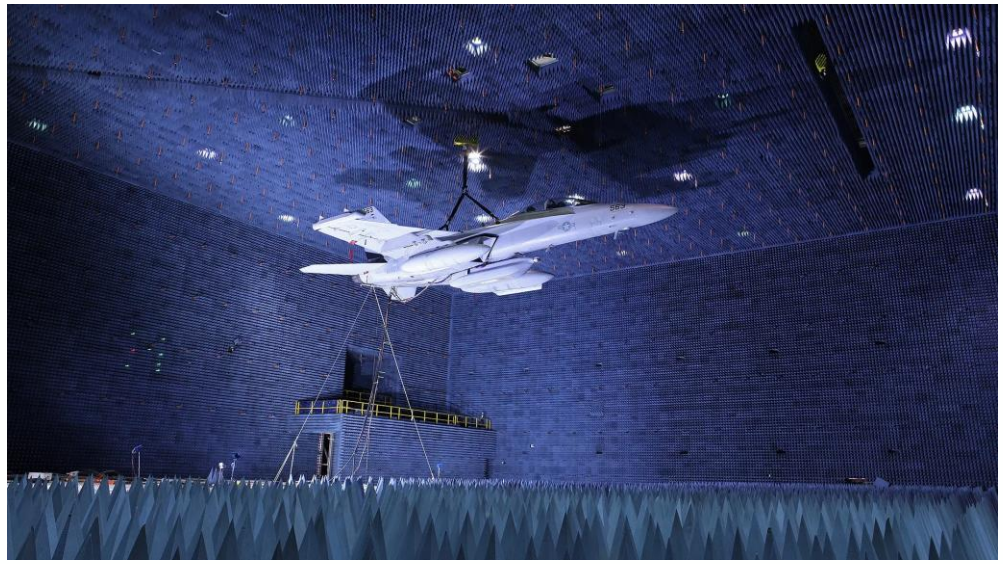


Introduction

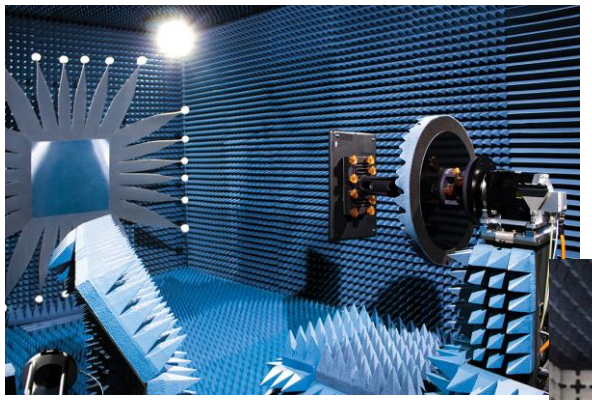
- RF anechoic chambers are used to provide a controlled environment for RF testing
- The level of control needed depends on several factors
  - Type of tests - EMC, Antenna pattern, OTA etc.
  - Frequency of operation - Low frequency increases absorber size, ferrites
  - Isolation needed - RF noise from outside the chamber
  - Level of reflections - reflections increase uncertainty
- Chambers are designed with either full or partial absorber lining.

Introduction

- Test Examples…
- Very Large chamber for large DUT
  - Jamming measurements
  - Full vehicle
- Small chamber
  - Antenna pattern measurements
  - OTA
- Standard Sized
  - Vehicle and component EMC



NAVAIR approved released photo



Why EMC Test ?

- Protect Licensed Electromagnetic Spectrum….

  - Maritime - 150KHz
  - Radio - 0.5MHz and 88MHz
  - Cellular - 700MHz to 60GHz (3G, 4G,LTE, 5G)
  - Satellite - 1.6GHz
  - WiFi - 2.4/5.8GHz
  - DSRC - 5.9GHz
  - RADAR - 24GHz / 79GHz / 81GHz

- … Make sure things work safely…

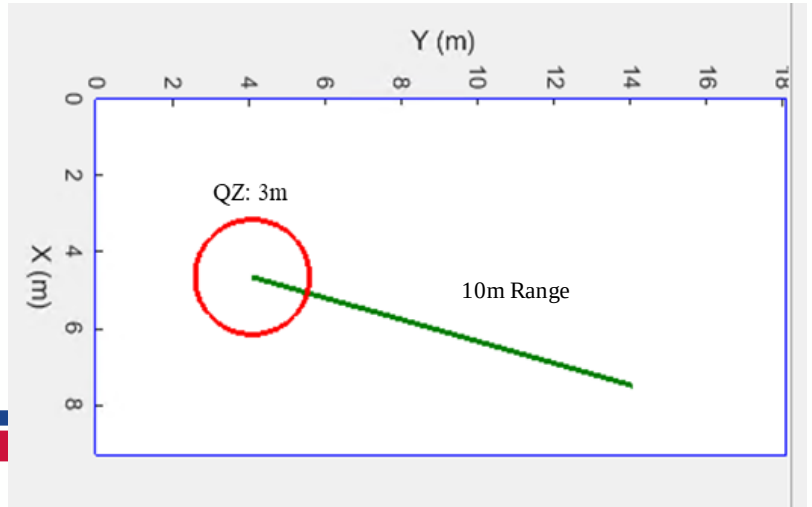




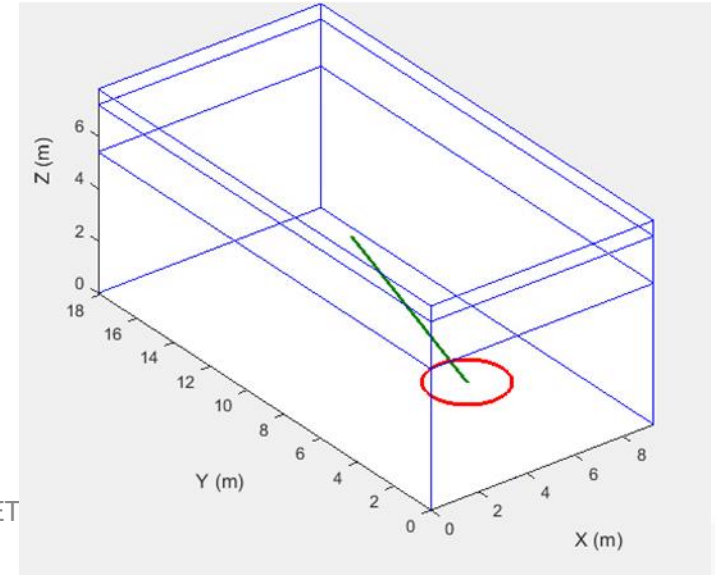

Images courtesy various internet sources

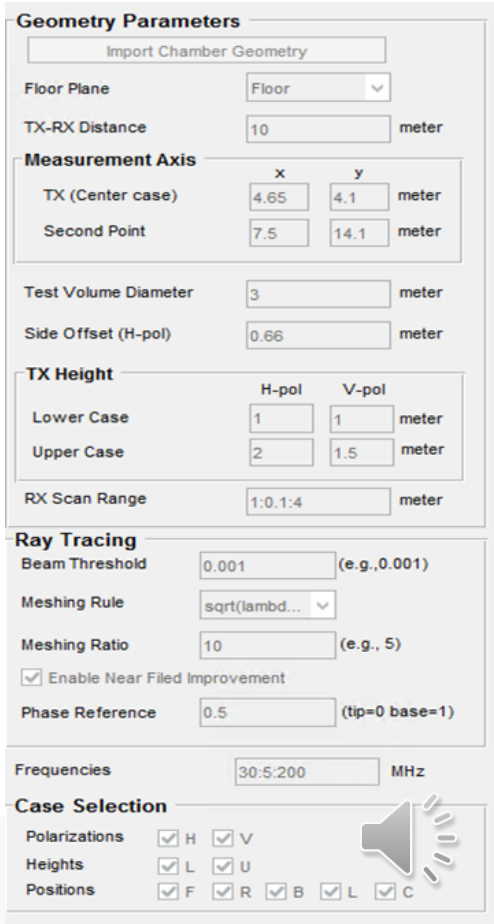
Chamber design

- The design of the chamber is based on several factors:
  - DUT size
  - Type of test
  - Test volume characteristics needed
- Based on these, the chamber is designed and modeled



Length: 18.1m
Width: 9.3m
Height: 7.8m

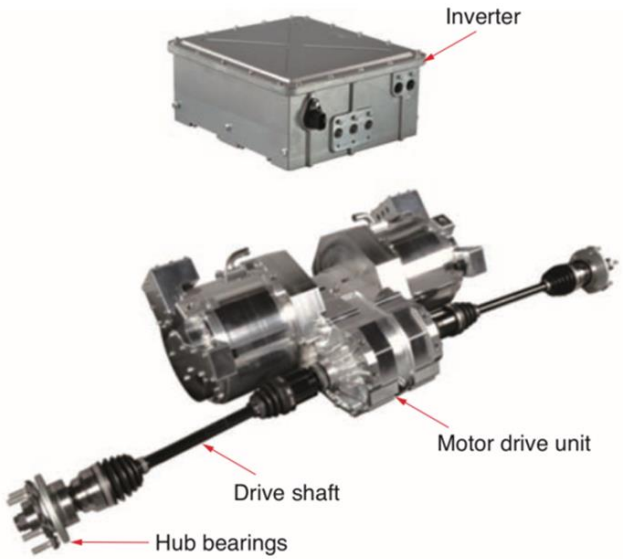




Automotive EMC Standards

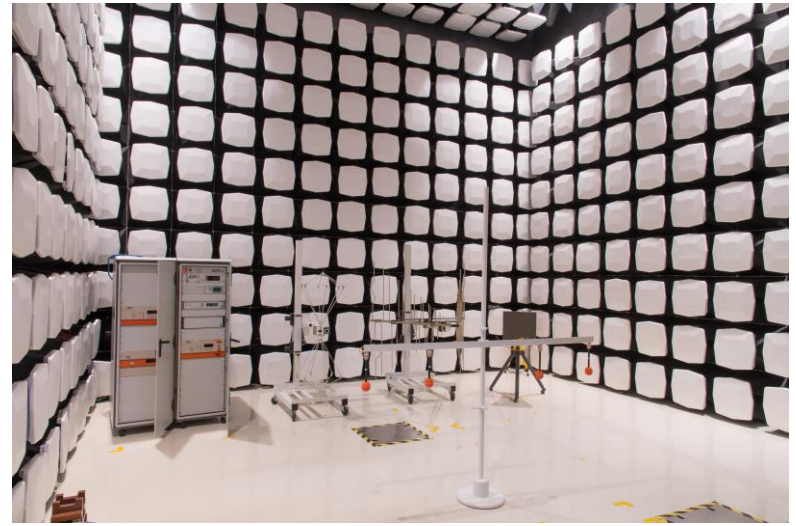
- Automotive EMC standards are developed to standardize the procedures and in some cases define limits for :
  - RF Emissions
  - RF Immunity

  for testing automotive components and vehicles
- There are standards that cover:
  - Electric/Electronic components
  - Full vehicles.



- Standards cover several classifications of components
- Several classes of vehicles – including EVs

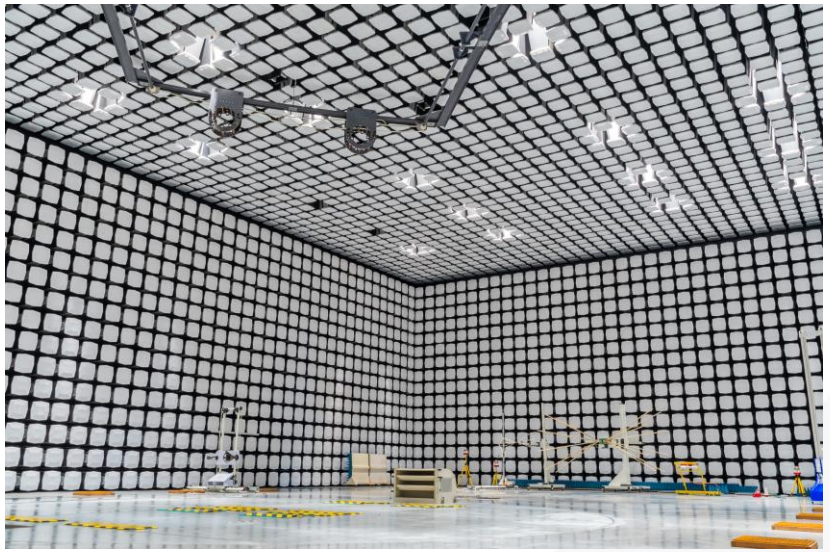
Standardized EMC Testing



- Most manufacturers (**OEMs)** have their own standards.
  - GMW 3097, 10th
  - FORD FMC 1278, Ed. 3
  - VOLVO STD 515-0003, Iss.5
  - HONDA,
  - PSA ….

- The main **industry** standards are
  - CISPR 12
  - CISPR 25
  - CISPR 36

  - ISO 11451-1,- 2,-3, -4, -5, -7, -8, -9, -10, -11
  - ISO 11452-2, -4, -7
  - ISO 7637
  - ECE Reg. 10.6



Chambers for EMC

- The IDEAL test site is free space or an open field - free of unwanted reflections and outside sources of RF.
  - Some open field EMC tests are done
    - With a reflective ground plane
    - With natural ground

- Test chambers are an accessible effective compromise
  - RF isolation
  - Control of internal reflections
  - Flexibility with test locations
- Standards define Chambers that are either SAC or FAR

IEC and CISPR Standards

- **IEC** – International Electrotechnical Commission –
  - Develop standards which reflect a consensus on definitions, methods, procedures and limits.
  - Standards may be adopted by countries to become national, regional or regulatory documents.

- **CISPR** – International Special Committee on Radio Interference (Comité International Special des Perturbations Radioélectriques)
  - Founded to set standards for controlling EMI
  - Part of the IEC

  - **TC** – Technical committees formed of volunteers tasked with developing specific standards
    - IEC TC 77 – Low Frequency Emissions (<9KHz) and low and High frequency Immunity, High Frequency Emissions (>9KHz) not covered by CISPR.
    - CISPR – High Frequency RF Emissions (>9KHz)

  - **CISPR/CIS/D** – Sub committee – Electromagnetic disturbances related to electric/electronic equipment on vehicles and internal combustion engine powered devices.

IEC and CISPR Standards

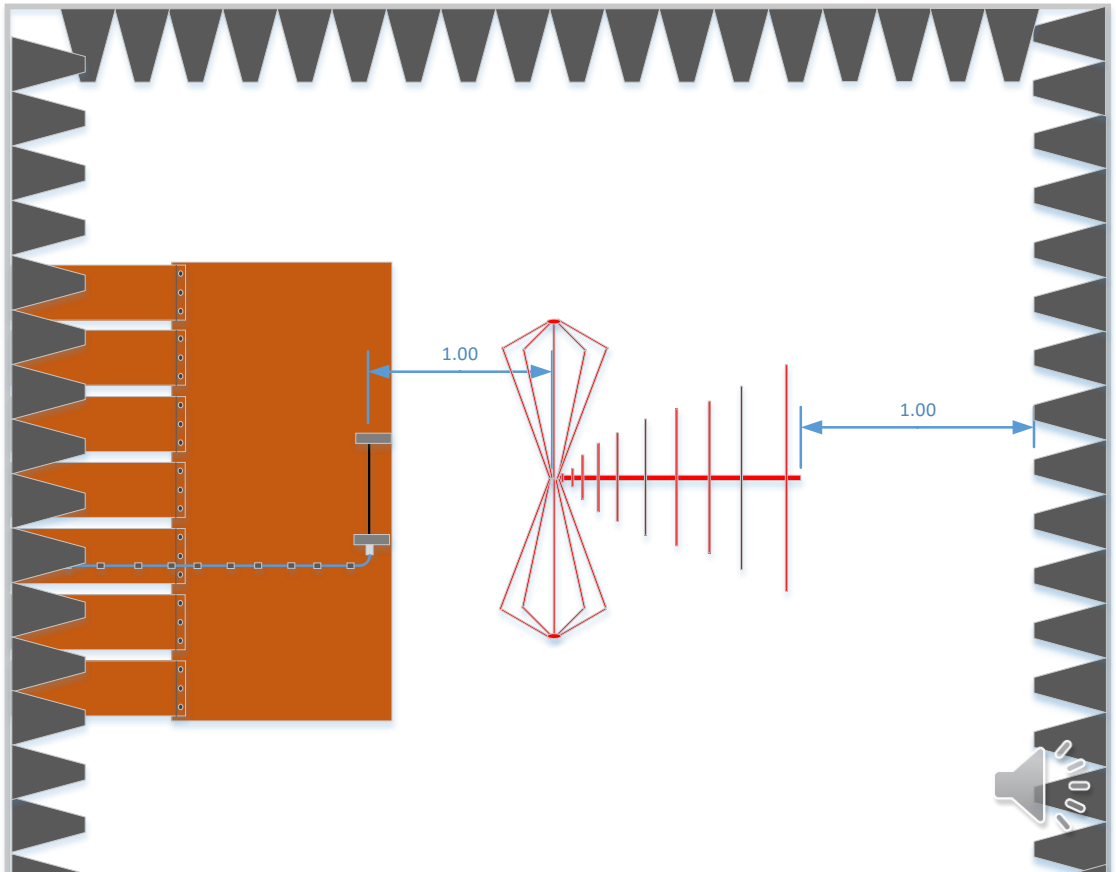
- Automotive chamber validation has been a topic of discussion for several years

- Validation methods for ALSEs
  - CISPR 25
  - CISPR 12
  - CISPR 36

- CISPR D and CISPR A – Joint task group working on chamber validation methods

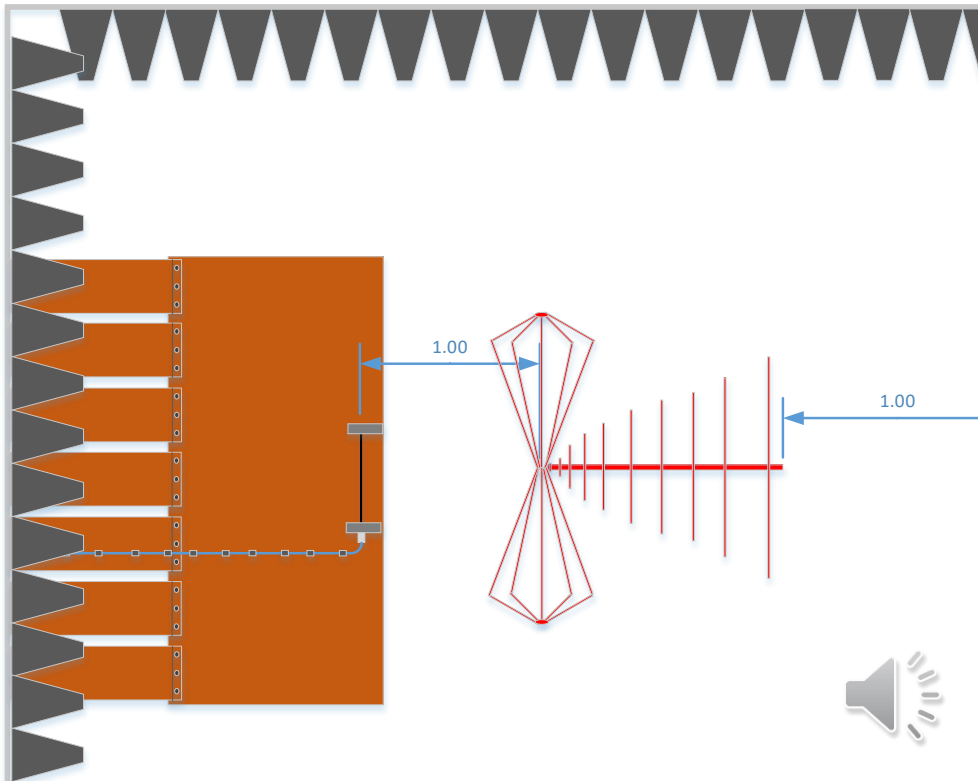
Chamber validation

- CISPR 25 introduced the LWM chamber validation
  - 150KHz to 1GHz
- In development : LWM 1- 6 GHz
  - Investigation of variables
  - Radiator characteristics
  - Impact of different Rx antennas
- Ongoing…



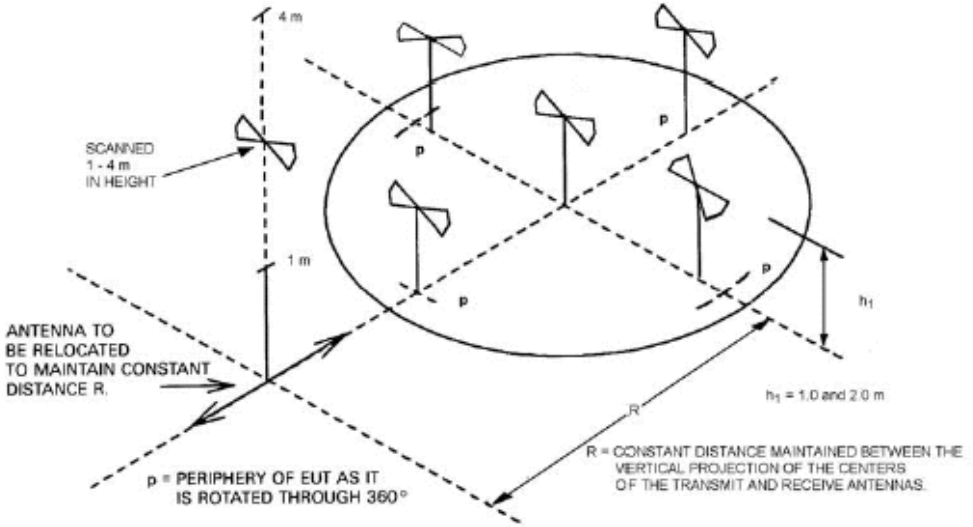
Chamber validation - CISPR 25

- Challenges…
- Chamber uses a large ground plane and a reflecting floor
  - Source of resonances
    - depend on chamber dimensions
    - Absorber performance
  - Antenna in the near field
    - Results depend on antenna type
    - Influenced by antenna location
- Desire to make the test meaningful!



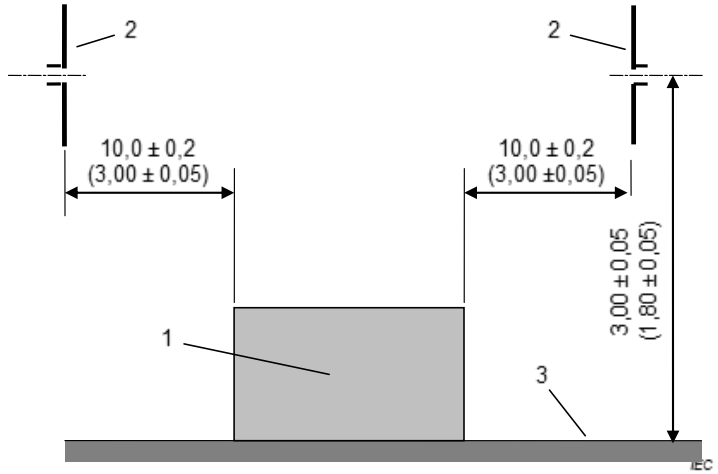
Site Validation – CISPR 12

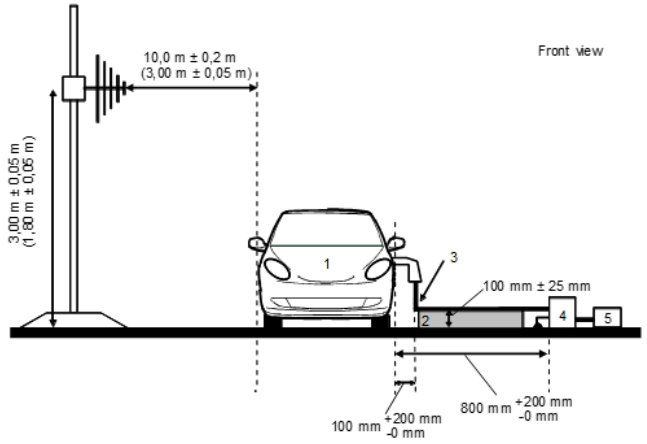
- CISPR 16.1.4 - NSA / sVSWR Validation
- CISPR 12 – No chamber Validation…
- In Development :
  - Validation methods for OTS, OATS, ALSEs
    - 30MHz - 1GHz
    - 1GHz - 6GHz
- Ongoing…



Site Validation – CISPR 12

- Challenges…
- There is no Rx antenna height scan.
  - Differs from CISPR 16.1.4
- Standard Covers ALSE, OATS and OTS
  - Testing of boats on water permitted
- Dividing line between vehicles and appliances
  - When plugged into a charging port/WPT
    - Other standards apply under certain condition





Extract from CISPR 12

ISO 11451 – Full Vehicle

ISO 11451 consists of the following parts, under the general title Road vehicles — **Vehicle test methods** for electrical disturbances from narrowband radiated electromagnetic energy:

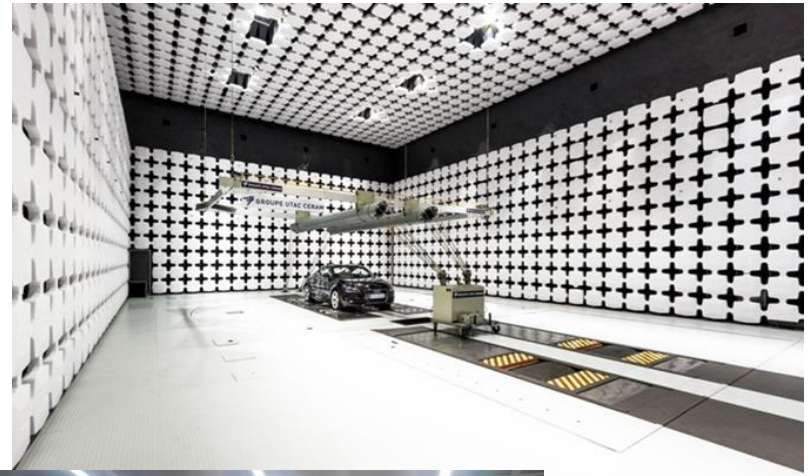
— Part 1: General principles and terminology

— Part 2: Off-vehicle radiation sources

— Part 3: On-board transmitter simulation

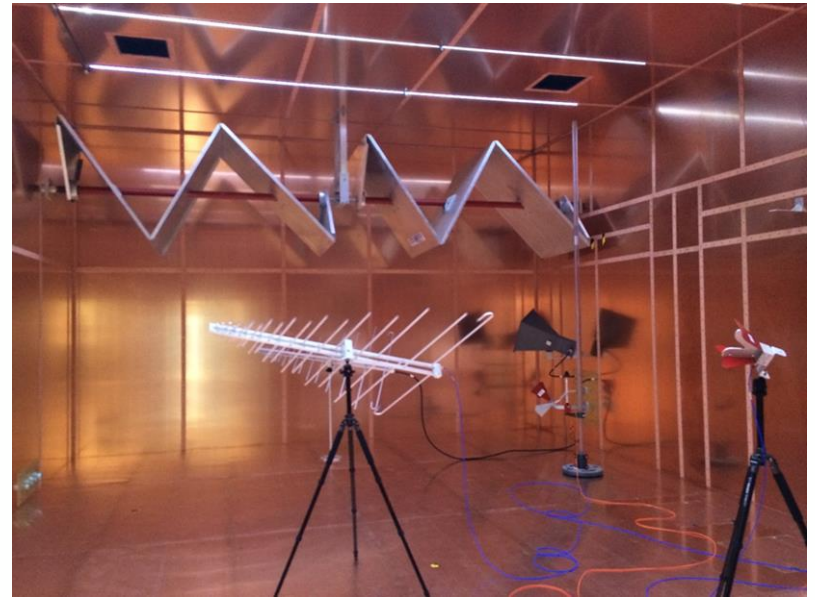
— Part 4: Bulk current injection (BCI)

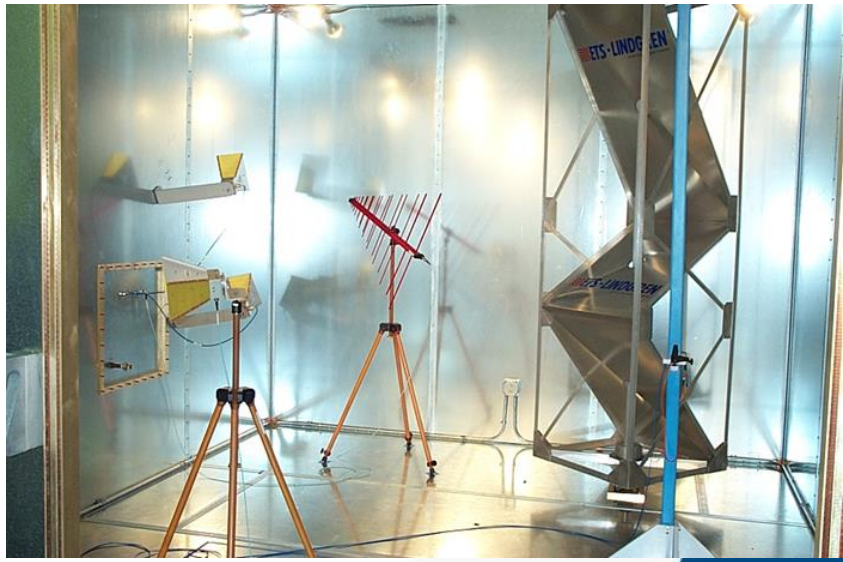
— **Part 5: Reverberation Chamber**



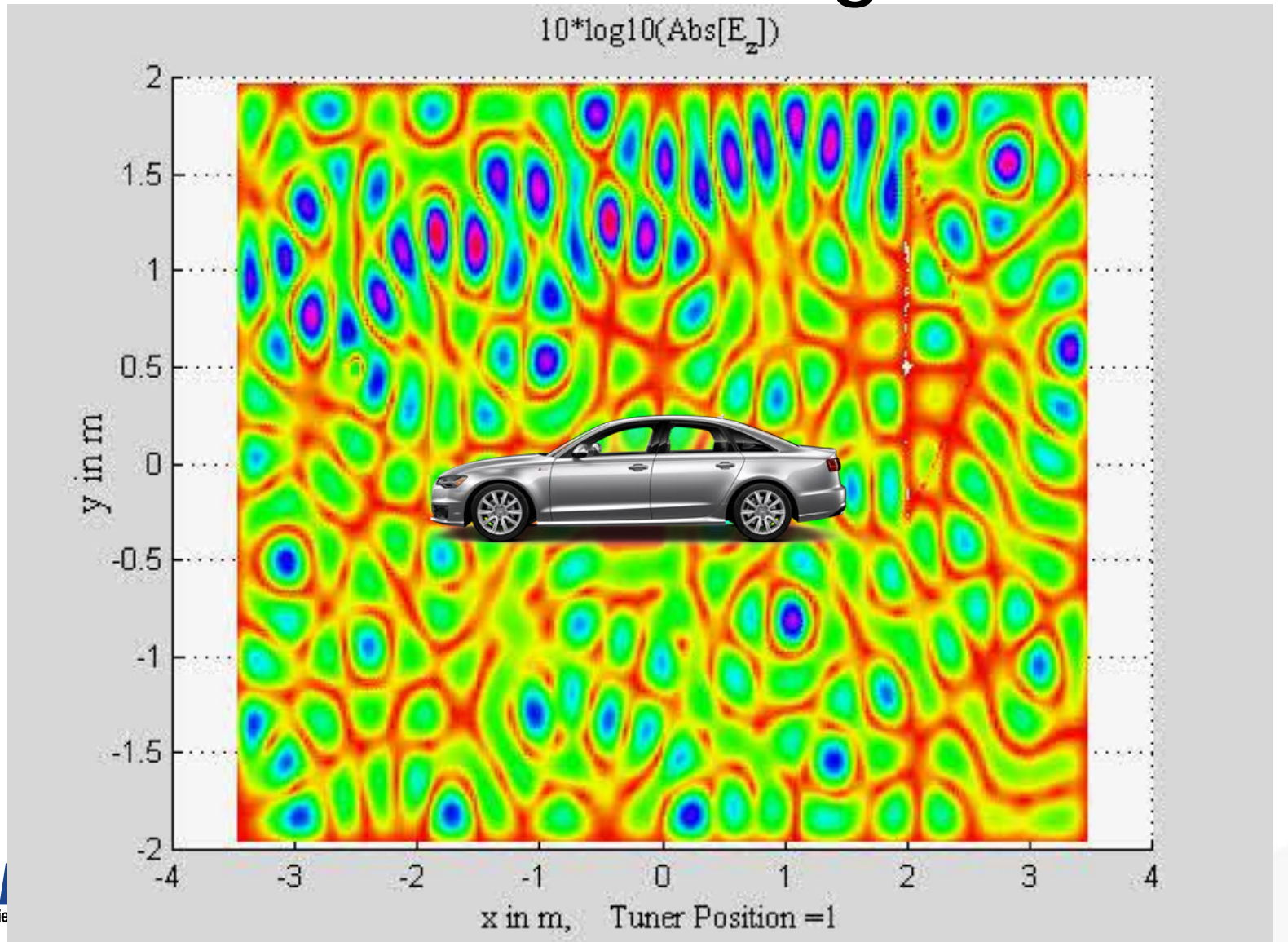
Chambers for EMC

- Recent addition of ISO 11451-5
  - Reverb chambers for vehicles
  - New procedures introduced
    - Fast stirring
    - VNA method
  - Extended low frequency
- Next revision of ISO 11452-11
  - Include some of the methods in 11451-5
  - Improve the usability of reverb chambers





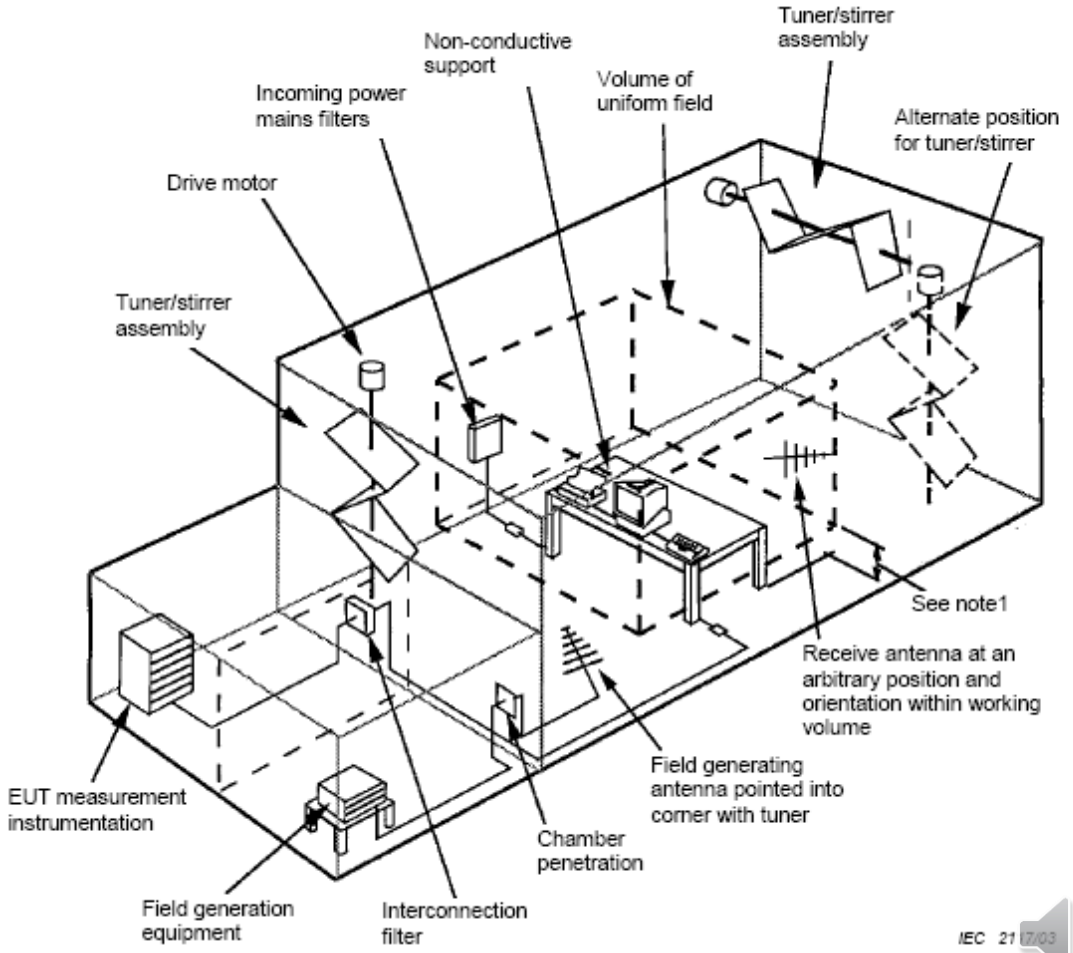
Reverb Chambers - Design



Model courtesy Chuck Bunting, Oklahoma State University

Reverb chamber validation

- Validation methods well defined
  - Based on IEC 61000-4-21
  - Other new methods introduced



Extract from IEC 61000-4-21 for reference

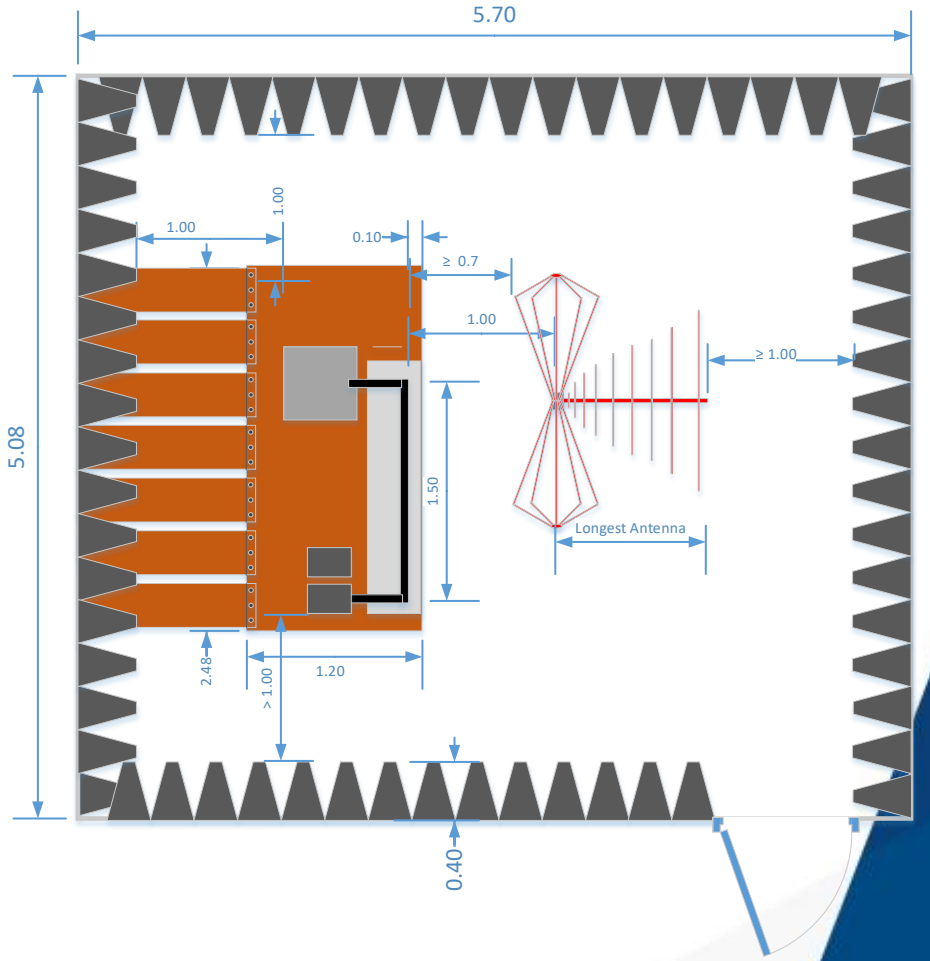
ISO 11452 – Component (ESA)

ISO 11452 consists of the following parts, under the general title Road vehicles — **Component test methods** for electrical disturbances from narrowband radiated electromagnetic energy:

– Part 1: General principles and terminology
– Part 2: Absorber-lined shielded enclosure
– Part 3: Transverse electromagnetic mode (TEM) cell
– Part 4: Harness excitation methods
– Part 5: Stripline
– Part 7: Direct radio frequency (RF) power injection
– Part 8: Immunity to magnetic fields
– Part 9: Portable transmitters
– Part 10: Immunity to conducted disturbances in the extended audio frequency range
– Part 11: Reverberation chamber

Chambers for EMC

- Chambers designed for component tests often use a test bench to support the DUT.
- Test bench is either metallic or non metallic.
- Chamber design and performance depends on the standard,
  - field uniformity
  - S_{21} based - Long Wire method.
- e.g. CISPR 25, ISO 11452-2



Chambers for EMC

- Challenges unique to e-Vehicles
  - Electric motors as source of magnetic interference
    - Rotating high current components
  - Inverter drives as source of electric interference
    - High frequency high power components
  - Vehicle components act as antennas
    - Interconnecting cables
    - Drive shaft
    - Half shaft
    - Wheel hubs
    - Chassis

Image courtesy caranddriver.com

Image courtesy BOSCH

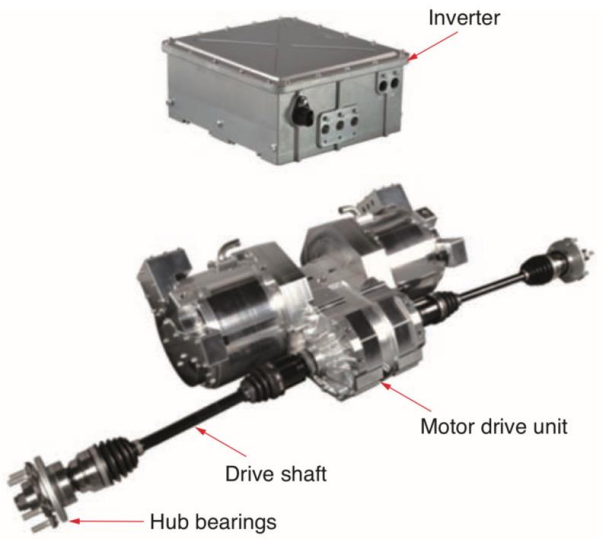
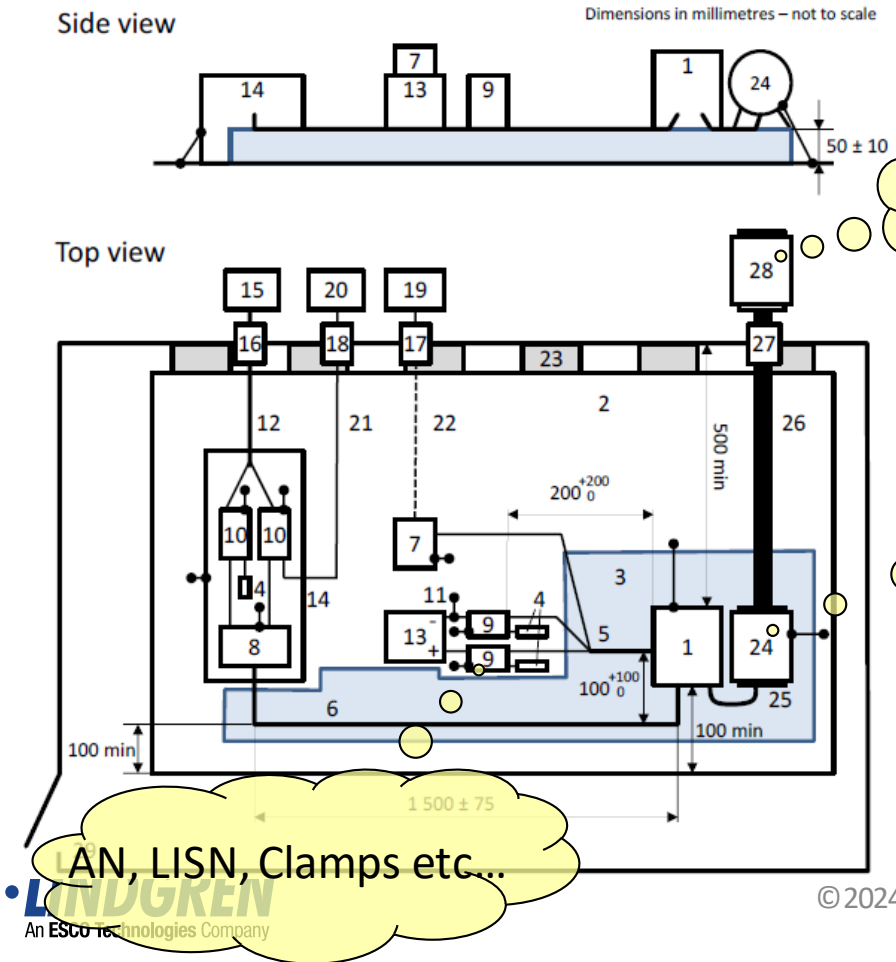


Image courtesy NTN

CISPR 25/ ISO Test Setup

- CISPR 25 Test setup for Conducted/Radiated emissions.



1	EUT
2	Ground plane
3	Low relative permittivity support ($\varepsilon_r \leq 1,4$) thickness ≥ 50 mm (a non-conductive support can be used for the electric motor)
4	50 Ω load
5	LV harness
6	HV lines (HV+, HV-)
7	LV load simulator
8	Impedance matching network (optional)
9	LV AN
10	HV AN
11	LV supply lines
12	HV supply lines
13	LV power supply 12 V / 24 V / 48 V
14	Additional shielded box

15	HV power supply (should be shielded if placed inside the shielded enclosure)
16	Power line filter
17	Fiber optic feed through
18	Bulk head connector
19	Stimulating and monitoring system
20	Measuring instrument
21	High quality coaxial cable e. g. double shielded (50 Ω)
22	Optical fibre
23	Ground straps
24	Electric motor
25	Three phase motor supply lines
26	Mechanical connection (e.g. non-conductive)
27	Filtered mechanical bearing
28	Brake or propulsion motor
29	Shielded enlosure

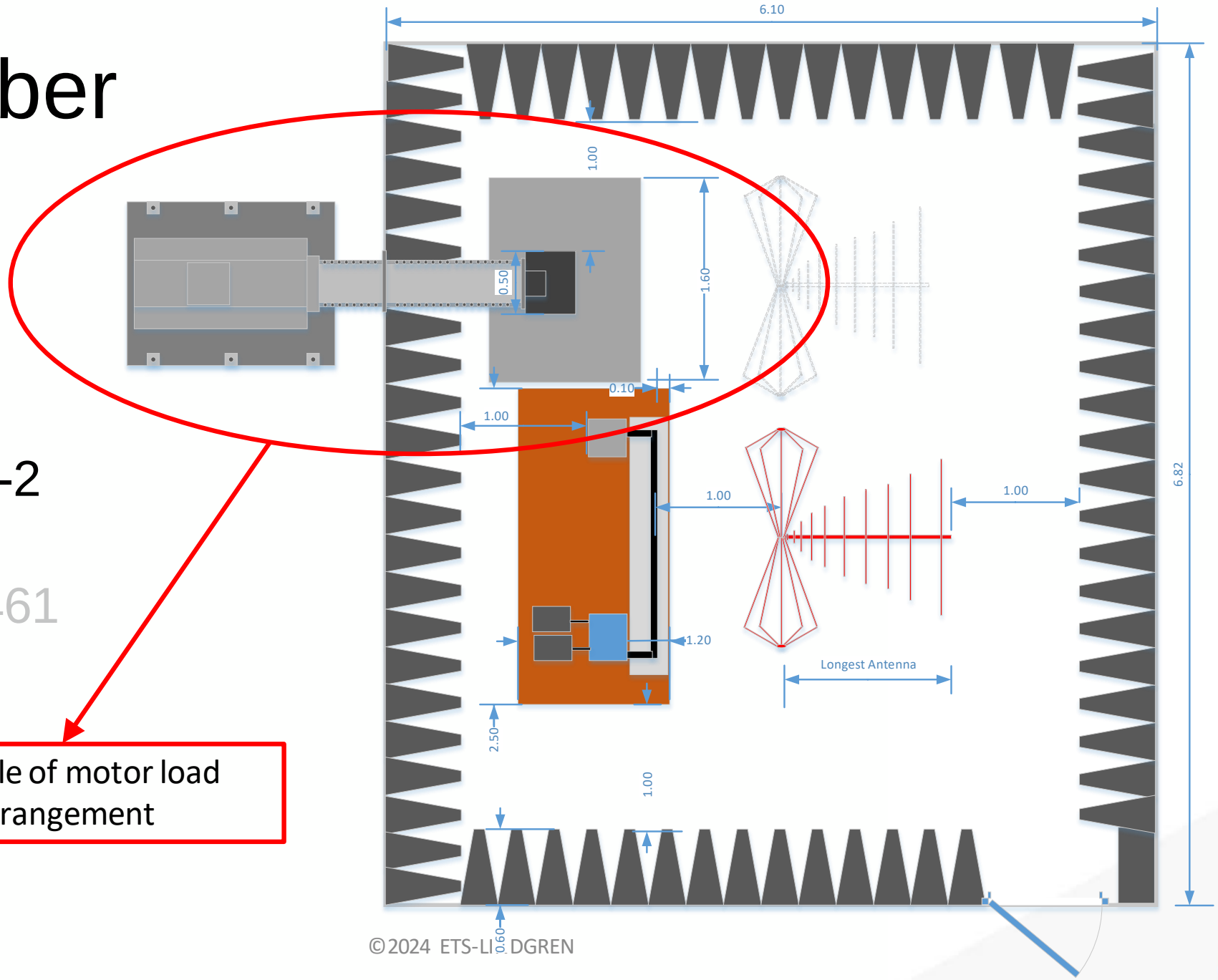
Dyno

Motor & Inverter

Illustration for reference from ECE R.10

Chamber

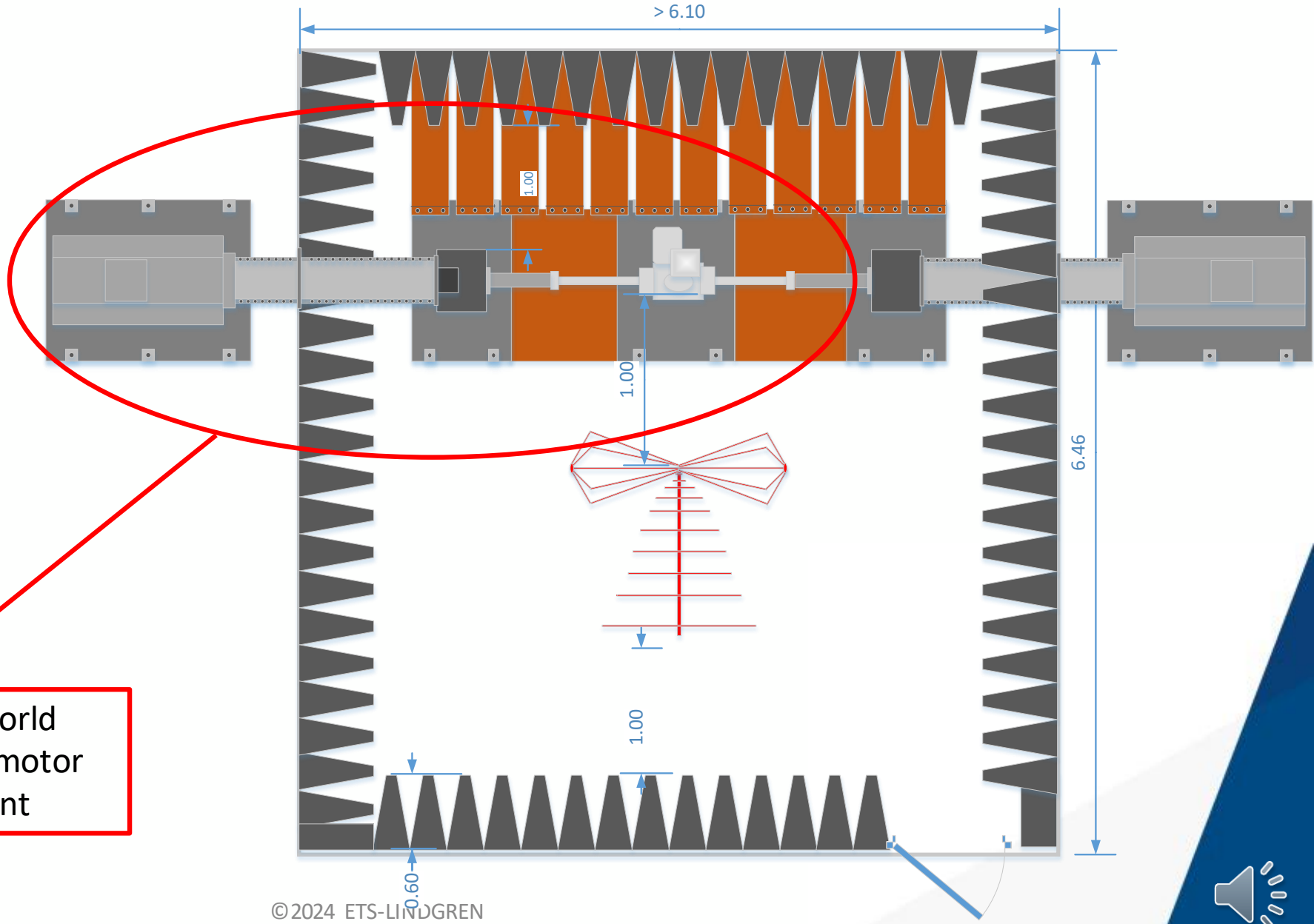
- E-Motor
- Standard -
  - CISPR 25
  - ISO 11452-2
  - DO160
  - MIL STD-461



Example of motor load arrangement

Chamber

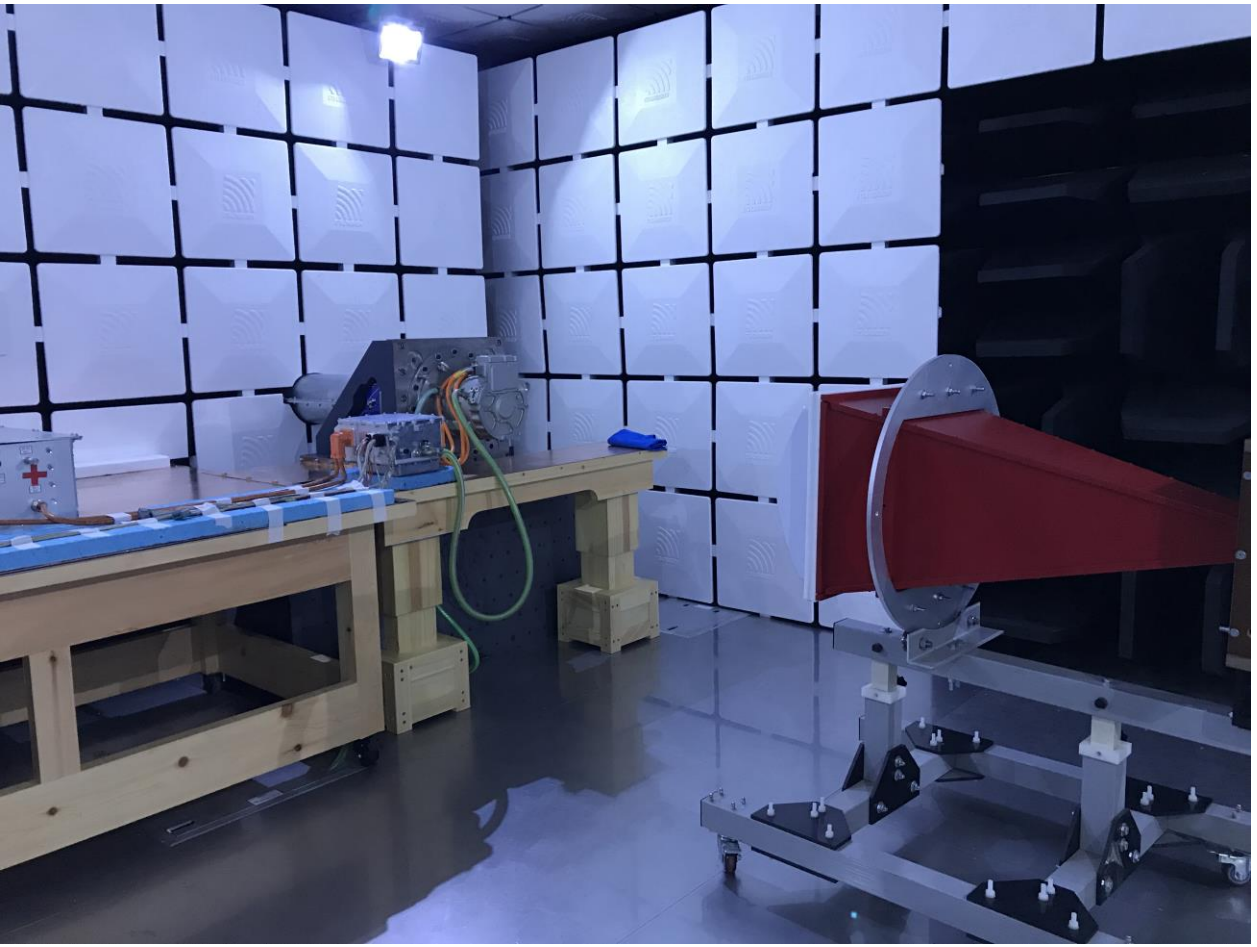
- E-Axle
- Standard -
  - CISPR 25
  - ISO 11452-2
  - DO160
  - MIL STD-461

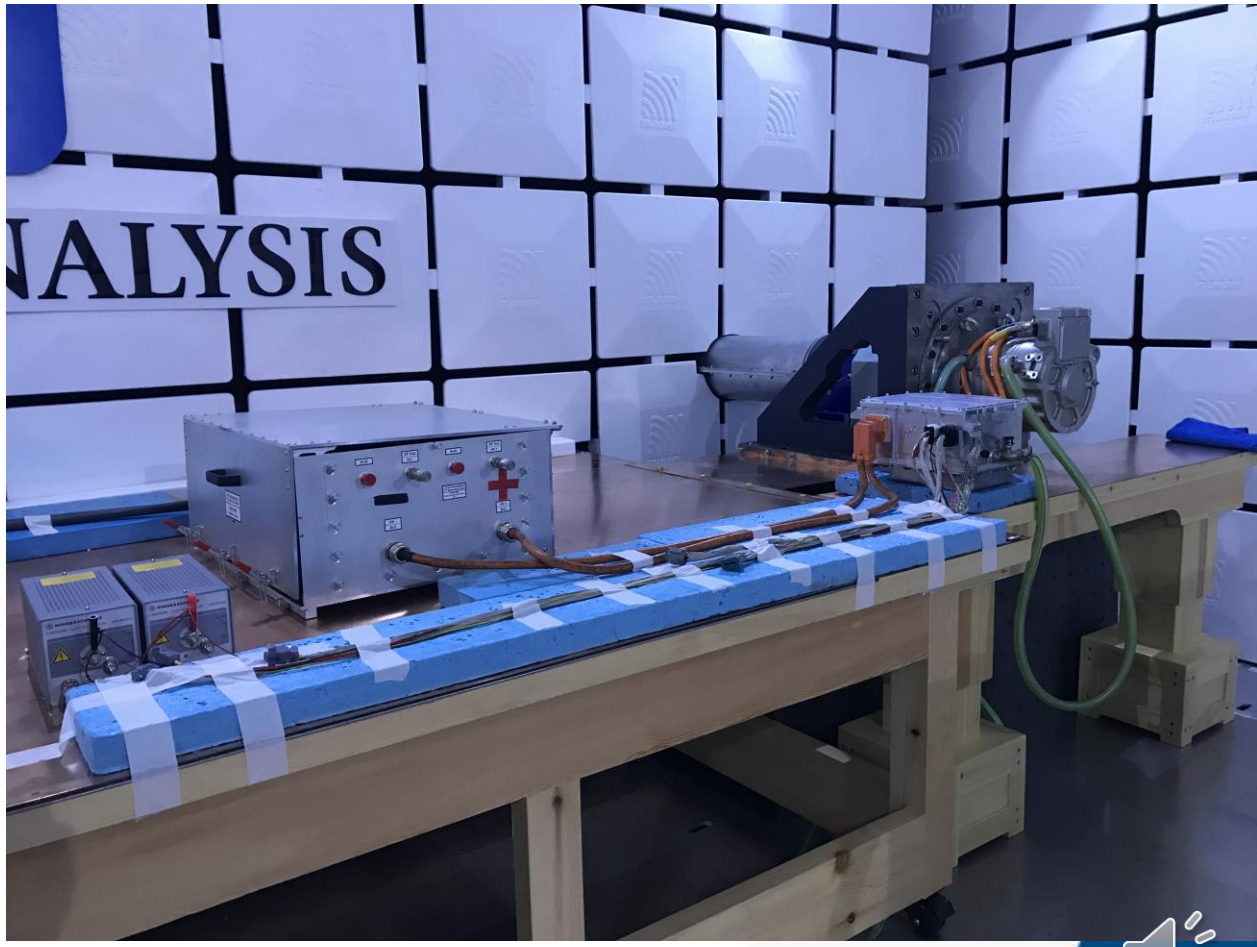


Example of real world implementation of motor load arrangement

CISPR 25/ ISO Test Setup

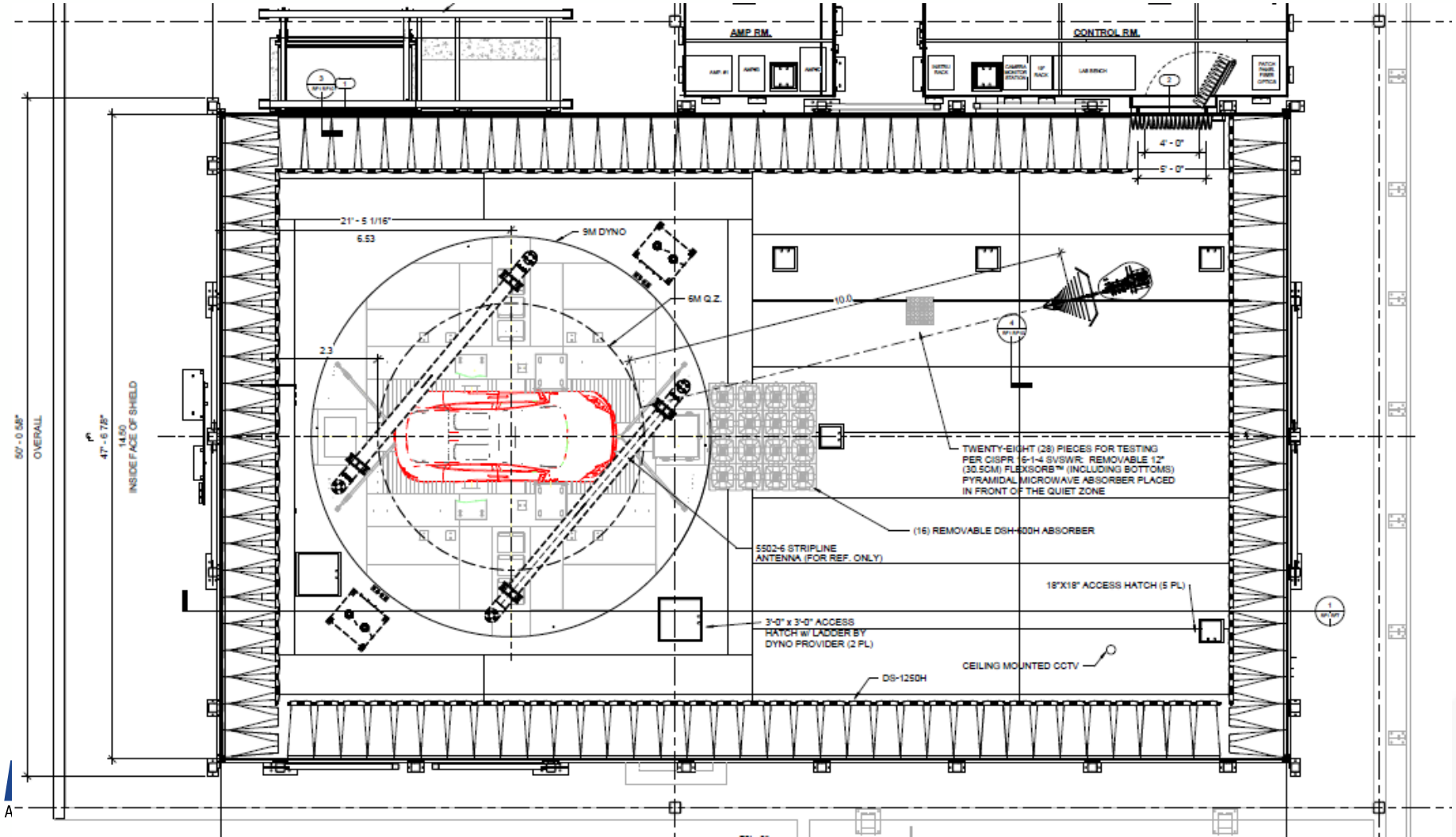
- E-motor Test setup





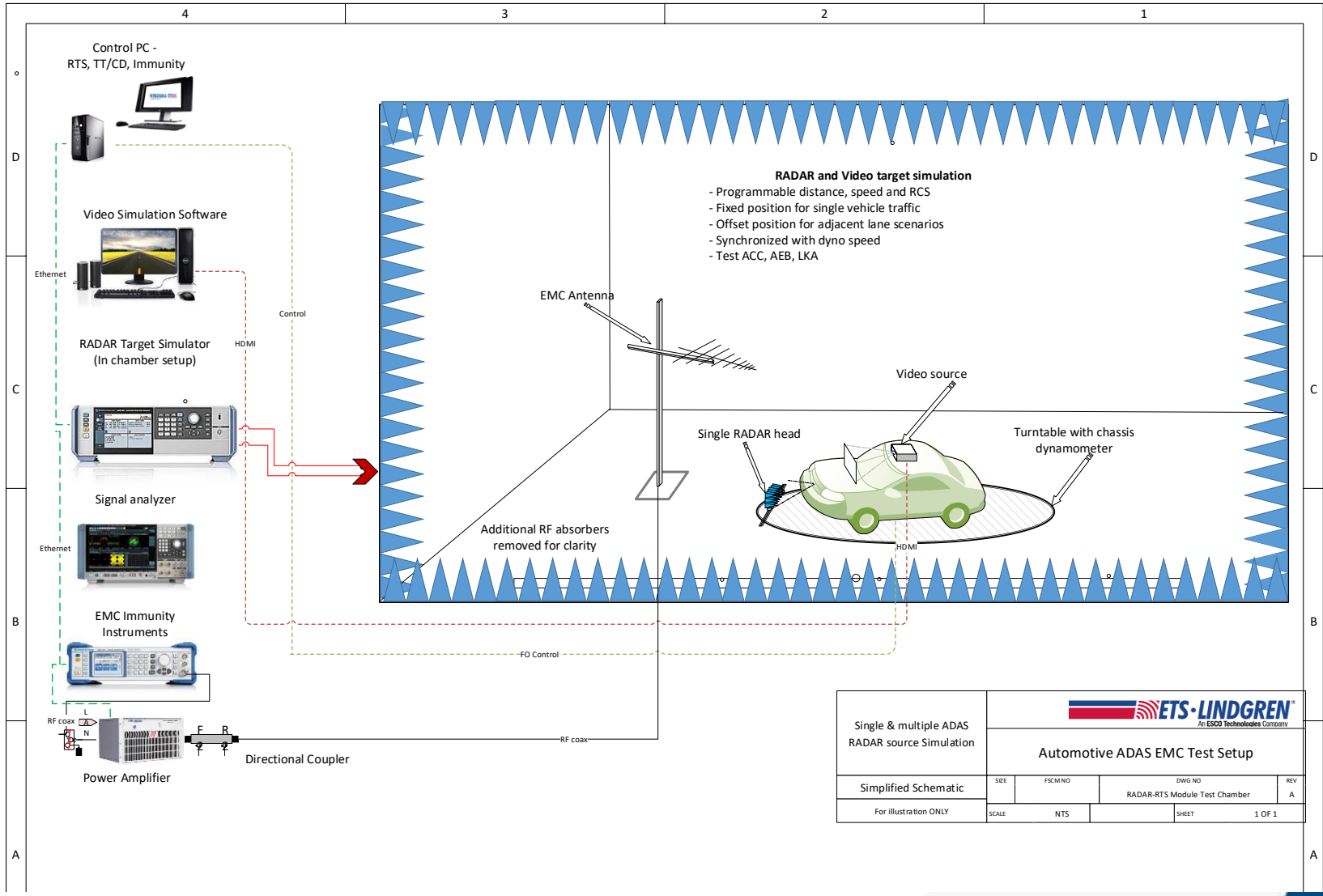
Full Vehicle Chamber

- Full 10 Meter Chamber example
  - Equipped with EMI/EMS Measurement Instrumentation, and EMC chassis dyno. Antennas.

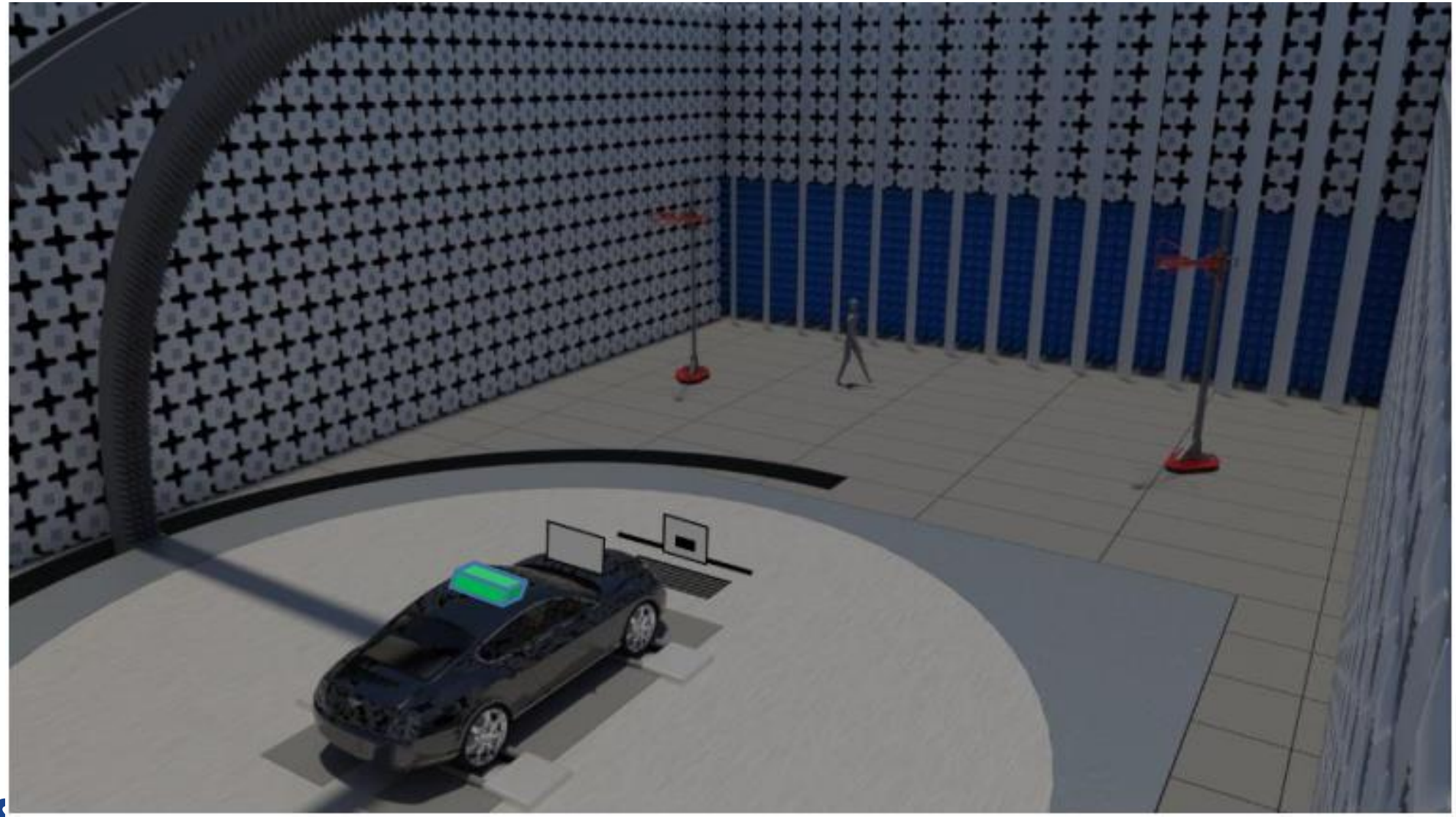


Chamber - ADAS

- In discussion

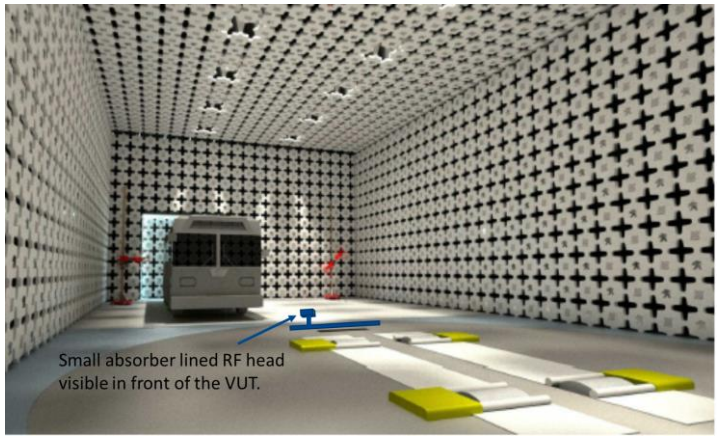


RTS & Video based ADAS simulation



Summary

- Chambers can be designed and optimized for specific test functions
- EMC measurements can be adapted to support
  - measurements at higher frequencies
  - ADAS functions - fitted with simulators
- Several new standards developments
  - Chamber validation procedures
  - ADAS function test procedure
- Performance needs of the chamber, drives the design



Thank You

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