

AUTOMOTIVE SOLUTIONS

CHAMBERS
COMPONENTS
TEST SYSTEMS
SOFTWARE
SERVICES



**COMMITTED TO A SMARTER,
MORE CONNECTED FUTURE**

 **ETS·LINDGREN**[®]
An ESCO Technologies Company

ETS-LINDGREN IS AN EXPERIENCED PARTNER YOU CAN TRUST

THE LEADER IN AUTOMOTIVE TEST AND MEASUREMENT CHAMBERS, COMPONENTS, SOFTWARE, AND SERVICES

Today's vehicle technology has been advancing at a rapid pace as modern vehicles are outfitted with an exceptional level of computerized automation and Advanced Driver Assistance Systems (ADAS), modern antenna technology for advanced communications, LIDAR, and RADAR. Beyond the typical EMC testing requirements, future vehicles will be even more state-of-the-art, relying increasingly on communication with other vehicles (V2V) and with infrastructure (V2I), requiring more advanced testing. These vehicles will also include multiple antennas of different types, covering a broad range of frequencies, protocols, and modulations. In parallel with this is the development of supporting Intelligent Transport System (ITS) test standards to be adopted by organizations such as ETSI.

The advancements do not end with more sophisticated assistance systems as manufacturers explore and develop alternatives to the combustion engine. E-vehicle technology has been advancing quickly, resulting in the need to develop new e-motor testing technologies. These technologies include testing e-motor components under variable load conditions using e-motor dynos. No matter your automotive testing needs, our team is here to assist you in developing smart, innovative solutions providing our customers the tools to rapidly develop products, perform regulatory tests, and deliver the next generation of automobiles to market. Whether you simply need some components to increase your current test capabilities or a turnkey test system, ETS-Lindgren has a solution. At ETS-Lindgren, we are *Committed to a Smarter, More Connected Future.*





CHAMBER SOLUTIONS

EMC CHAMBERS

When it comes to EMC vehicle testing, ETS-Lindgren is the clear leader. Our solutions range from anechoic chambers for component testing to large format anechoic chambers integrated with dynamometers for full vehicle testing. From reverb chambers with superior isotropy and homogeneity providing high measurement repeatability to e-motor solutions for performing e-motor component testing to e-motor full vehicle test systems complying with the latest version of automotive standards.

ETS-Lindgren offers many standard solutions to help our customers perform testing and quickly deliver to market. Our EMC Test Chambers include:

- Free-space Anechoic Chamber Test-site (FACT™) Chambers
- E-Motor and E-Vehicle Chambers
- Statistical Mode Averaging Reverberation Test-Site (SMART™) Reverberation (Reverb) Chambers

At ETS-Lindgren, we also understand that testing needs change and standard solutions do not always fit the need. Our capable experts can assist you in developing solutions that will meet your evolving needs, ensuring your success in developing and testing new vehicles and vehicle components. Whether you need a solution for traditional combustion or for e-vehicle and hydrogen fuel cells, ETS-Lindgren is your ideal partner.

FACT 10 EMC Test Chamber

Measurement frequency range: 26 MHz (10 kHz optional) to 18 GHz

Full compliance testing for radiated emissions and radiated immunity

ETS-Lindgren FACT 10 Chambers, for Full Compliance testing, offer semi-anechoic radiated emissions (RE) and fully anechoic radiated immunity (RI) compliance test capability for most international EMC compliance regulations.

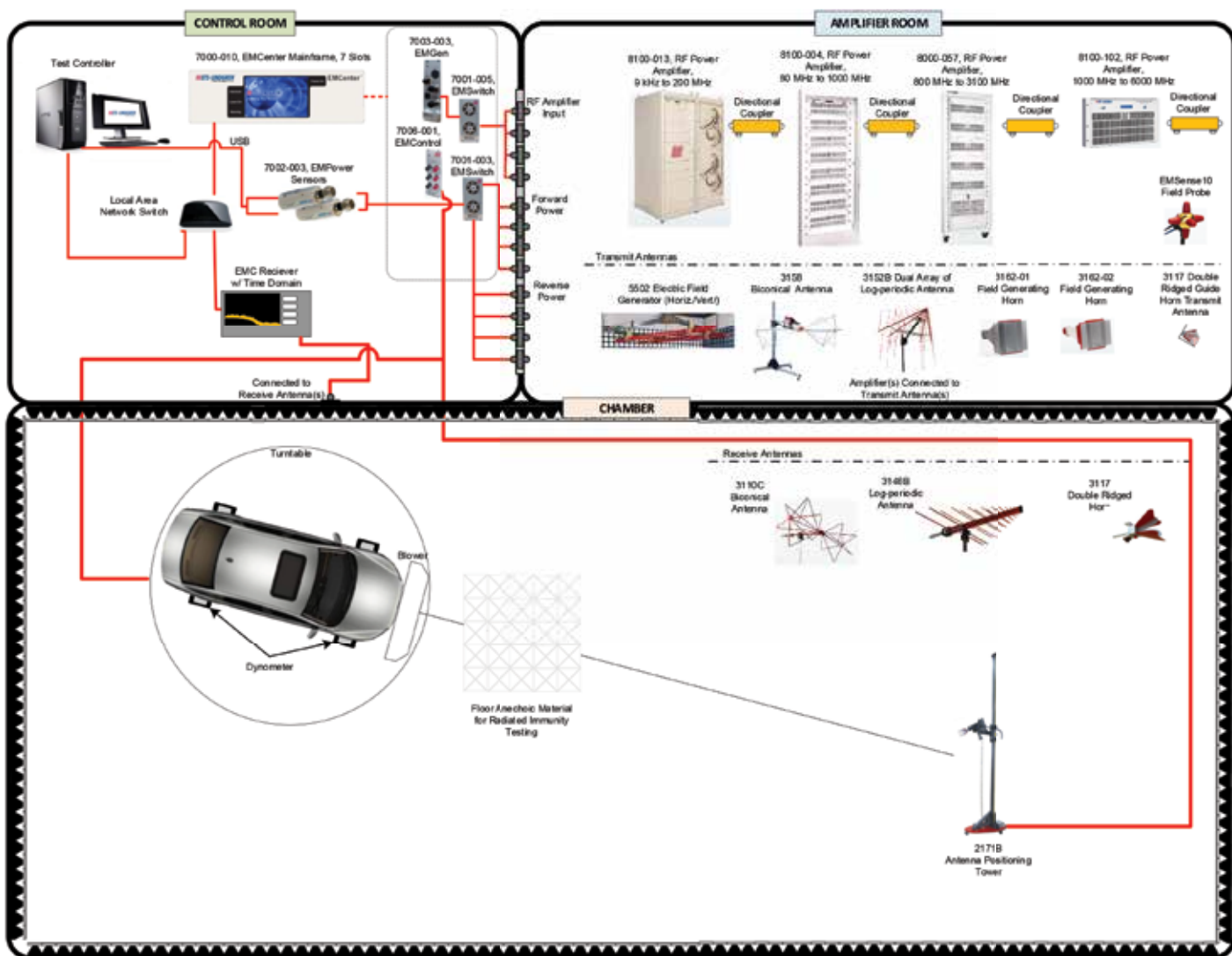
The chamber's comparatively small overall size results from the use of a hybrid absorber and ferrite tile combination, which require less volumetric space than traditional absorbers. ETS-Lindgren FACT 10 chambers are large enough to perform 3 meter and 10 meter emission measurements and can also accommodate large diameter turntables for testing substantial equipment under test (EUT). ETS-Lindgren FACT 10 chambers are the perfect choice when full compliance 10 meter range testing is required.

Standards

- Full Compliance Testing for Radiated Emissions:
 - ANSI C63.4
 - FCC Parts 15 and 18
 - EN 50147-2
 - CISPR 16/EN55016
 - CISPR 36/EN55036
 - CISPR 12/EN55012
 - Bellcore GR-1089
- Full Compliance Testing for Radiated Immunity:
 - SAE J1113
 - ISO 11451-2



FACT 10 Chamber System Layout



Chamber Specifications

Typical Specifications	FACT 10-3.0 Plus	FACT 10-3.0 Premium	FACT 10-4.0 Standard	FACT 10-4.0 Plus	FACT 10-4.0 Premium	FACT 10-6.0 Plus
Chamber Size (Estimated Overall)	19.9 m x 12.2 m x 9.7 m (65.3 ft x 40.0 ft x 31.8 ft)	19.9 m x 12.2 m x 9.7 m (65.3 ft x 40.0 ft x 31.8 ft)	20.5 m x 12.2 m x 9.7 m (67.3 ft x 40.0 ft x 31.8 ft)	20.5 m x 12.8 m x 9.7 m (67.3 ft x 42.0 ft x 31.8 ft)	20.5 m x 12.8 m x 9.7 m (67.3 ft x 42.0 ft x 31.8 ft)	22.4 m x 13.9 m x 9.7 m (73.3 ft x 45.7 ft x 31.8 ft)
Chamber Size (Nominal Interior)	19.4 m x 11.5 m x 8.5 m (63.5 ft x 37.8 ft x 27.8 ft)	19.4 m x 11.5 m x 8.5 m (63.5 ft x 37.8 ft x 27.8 ft)	19.9 m x 11.0 m x 6.7 m (65.4 ft x 35.9 ft x 21.8 ft)	19.9 m x 12.1 m x 8.5 m (65.4 ft x 39.8 ft x 27.8 ft)	19.9 m x 12.1 m x 8.5 m (65.4 ft x 39.8 ft x 27.8 ft)	21.8 m x 13.3 m x 8.5 m (71.5 ft x 43.5 ft x 27.8 ft)
Door Size	3.5 m x 3.0 m (11.5 ft x 9.8 ft)	3.5 m x 3.0 m (11.5 ft x 9.8 ft)	4.5 m x 3.5 m (14.8 ft x 11.5 ft)	4.5 m x 3.5 m (14.8 ft x 11.5 ft)	4.5 m x 3.5 m (14.8 ft x 11.5 ft)	6.5 m x 4.0 m (21.3 ft x 13.1 ft)
Test Volume	3.0 m diameter x 2.5 m high (9.8 ft x 8.2 ft)	3.0 m diameter x 2.5 m high (9.8 ft x 8.2 ft)	4.0 m diameter x 2.5 m high (13.1 ft x 8.2 ft)	4.0 m diameter x 3.0 m high (13.1 ft x 9.8 ft)	4.0 m diameter x 3.0 m high (13.1 ft x 9.8 ft)	6.0 m diameter x 3.5 m high (19.7 ft x 11.5 ft)
Absorber Treatment	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250

FACT 25 EMC Test Chamber

Measurement frequency range: 150 KHz (70 MHz optional) to 18 GHz

Automotive component testing in a semi-anechoic environment

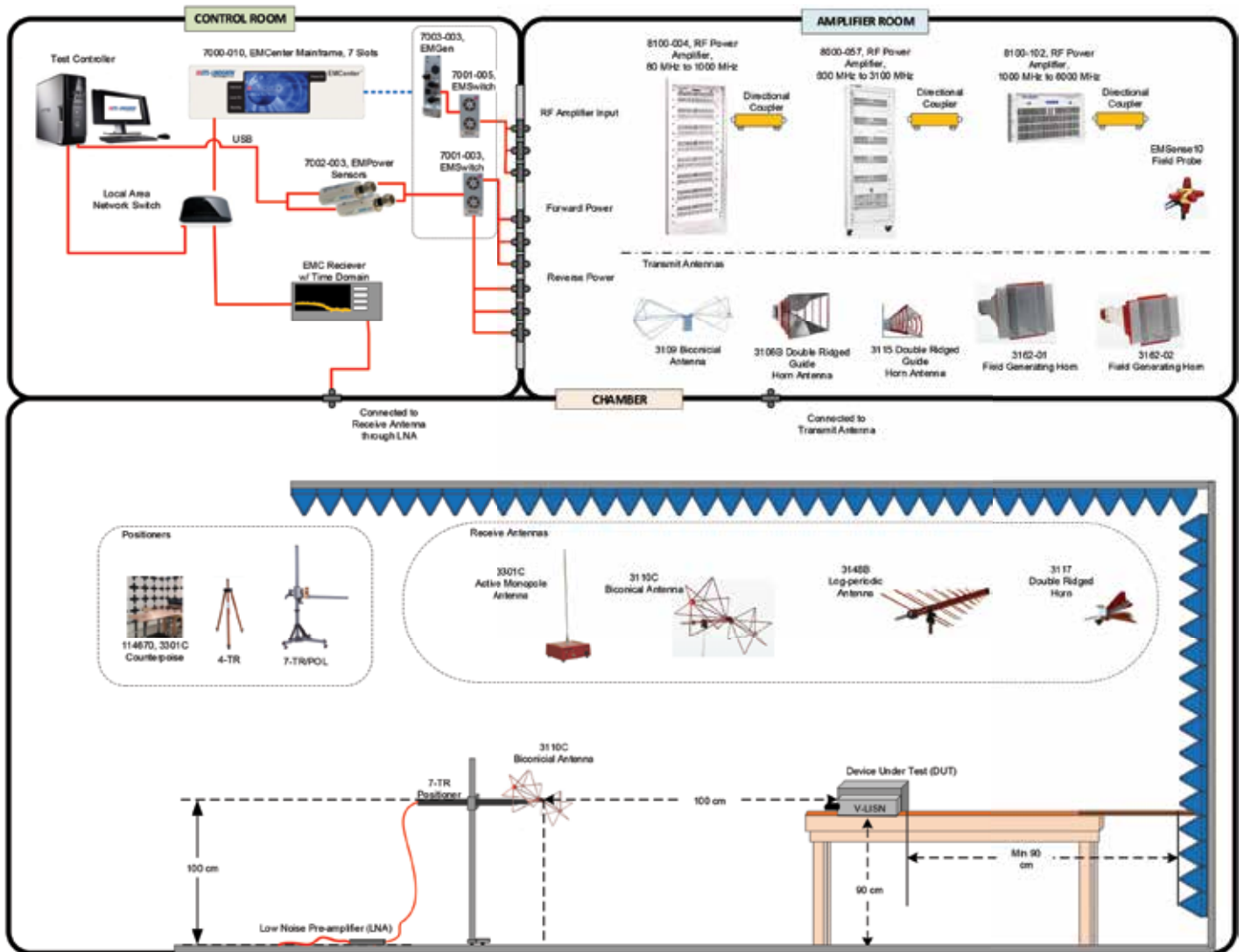
ETS-Lindgren's FACT 25 is an RF shielded semi-anechoic chamber providing an ideal environment for compliant CISPR 25 testing. The chamber is specifically designed for CISPR 25 Ed.5 (2021) and ISO 11452-2 Ed.3 (2019) measurements of automotive components. The RF performance is achieved with a full wall and ceiling lining of better than -6 dB absorber reflectivity from 70 MHz to 5.9 GHz, and can be validated using the procedures described in the CISPR 25 Ed.5 standard. The chamber provides an environment for EMC radiated emissions and immunity measurements up to 18 GHz with options for testing to 40 GHz. Validation of the RF shielded enclosure is performed at 1 GHz plane wave field. Optional shielding enhancements are available for increased RF attenuation above 10 GHz. Validation above 1 GHz is also optional, if desired. Additionally, the chamber dimensions can be increased (optional) to support larger DUT's and on load electric vehicle (EV) component testing.

Standards

- Full Compliance Testing for Radiated Emissions:
 - CISPR 25
- Vehicle Component Testing:
 - ISO 11452-2
 - ISO 7637
 - ISO 10605 (Conducted)



FACT 25 Chamber Layout



Chamber Specifications

Typical Specifications	FACT 25-300	FACT 25-400
Chamber Size (Estimated Overall)	5.6 m x 5.0 m x 3.4 m (18.5 ft x 16.5 ft x 11.2 ft)	5.9 m x 5.3 m x 3.8 m (19.4 ft x 17.4 ft x 12.5 ft)
Chamber Size (Nominal Interior)	5.5 m x 4.9 m x 3.2 m (18.0 ft x 16.0 ft x 10.5 ft)	5.7 m x 5.2 m x 3.6 m (18.7 ft x 18.0 ft x 11.8 ft)
Door Size	1.2 m x 2.1 m (4.0 ft x 7.0 ft)	1.2 m x 2.1 m (4.0 ft x 7.0 ft)
Test Volume (Typical)	0.5 m x 0.5 m x 0.2 m (1.6 ft x 1.6 ft x 0.7 ft)	0.5 m x 0.5 m x 0.2 m (1.6 ft x 1.6 ft x 0.7 ft)
Absorber Treatment	FS-300	DSH-400

E-Vehicle Test Chamber

Measurement frequency range: 150 kHz (10 kHz optional) to 18 GHz

Automotive component testing with charging infrastructure

Introducing the ETS-Lindgren Test Chamber adapted to support e-vehicle charging and REESS charging mode testing, an advanced solution designed to meet the demanding requirements of electromagnetic testing in the electric vehicle industry. With an impressive measurement frequency range of 150 kHz to 40 GHz as an option, this test chamber offers exceptional capabilities for precise and comprehensive evaluations.

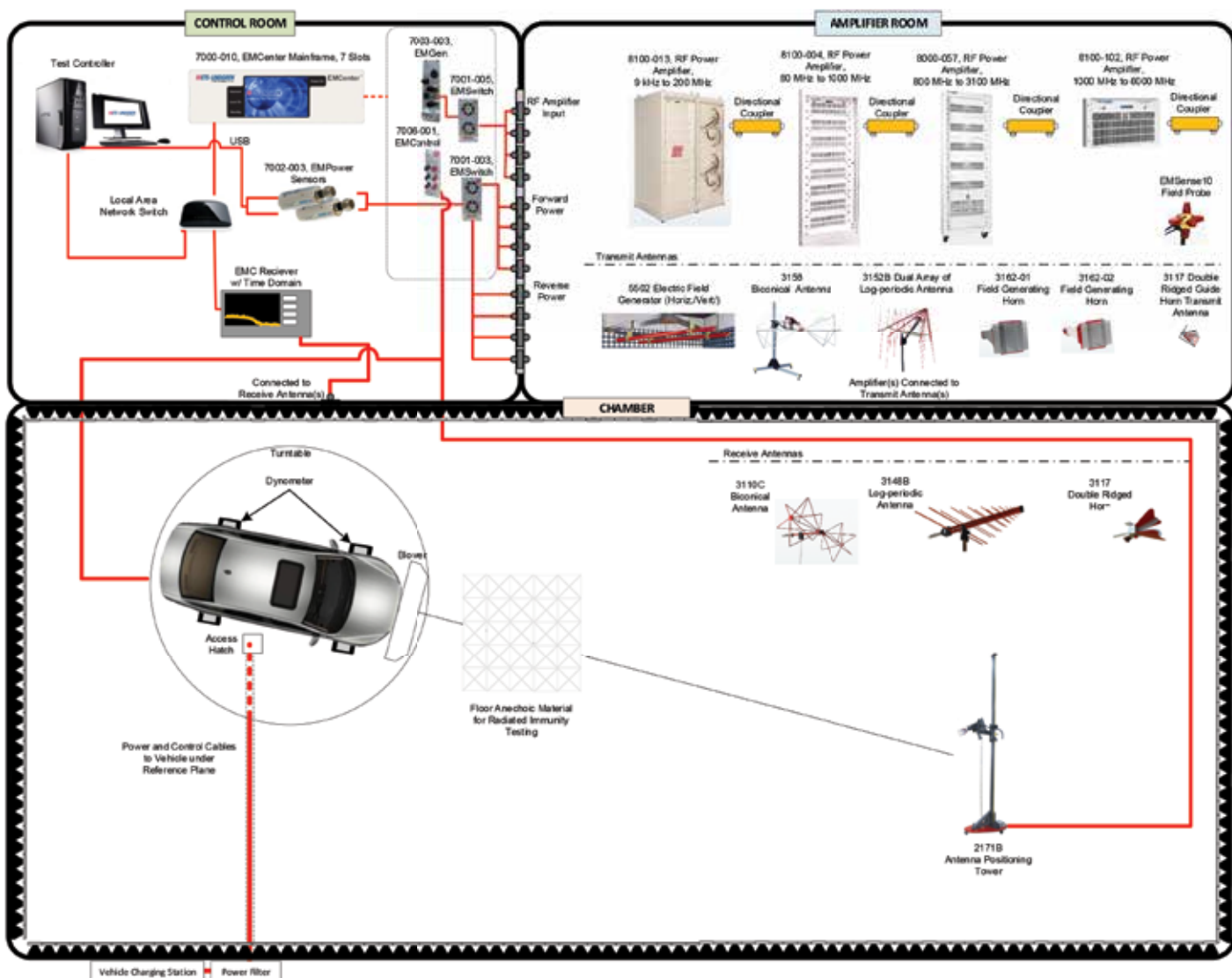
Our E-Vehicle Test Chamber provides a controlled environment, enabling accurate and repeatable assessments of your vehicle's electromagnetic performance. Whether you need to evaluate emissions or assess your vehicle's resilience to external electromagnetic interference, our test chamber empowers you to make informed decisions based on accurate measurements.

Standards

- Full Compliance Testing for Radiated Emissions:
 - ANSI C63.4
 - FCC Parts 15 and 18
 - EN 50147-2
 - CISPR 12/EN55012
 - CISPR 16/EN55016
 - CISPR 36/EN55036
 - Bellcore GR-1089
- Full Compliance Testing for Radiated Immunity:
 - SAE J1113
 - ISO 11451-2



E-Vehicle Chamber System Layout



Chamber Specifications

Typical Specifications	FACT 10-3.0 Plus	FACT 10-3.0 Premium	FACT 10-4.0 Standard	FACT 10-4.0 Plus	FACT 10-4.0 Premium	FACT 10-6.0 Plus
Chamber Size (Estimated Overall)	19.9 m x 12.2 m x 9.7 m (65.3 ft x 40.0 ft x 31.8 ft)	19.9 m x 12.2 m x 9.7 m (65.3 ft x 40.0 ft x 31.8 ft)	20.5 m x 12.2 m x 9.7 m (67.3 ft x 40.0 ft x 31.8 ft)	20.5 m x 12.8 m x 9.7 m (67.3 ft x 42.0 ft x 31.8 ft)	20.5 m x 12.8 m x 9.7 m (67.3 ft x 42.0 ft x 31.8 ft)	22.4 m x 13.9 m x 9.7 m (73.3 ft x 45.7 ft x 31.8 ft)
Chamber Size (Nominal Interior)	19.4 m x 11.5 m x 8.5 m (63.5 ft x 37.8 ft x 27.8 ft)	19.4 m x 11.5 m x 8.5 m (63.5 ft x 37.8 ft x 27.8 ft)	19.9 m x 11.0 m x 6.7 m (65.4 ft x 35.9 ft x 21.8 ft)	19.9 m x 12.1 m x 8.5 m (65.4 ft x 39.8 ft x 27.8 ft)	19.9 m x 12.1 m x 8.5 m (65.4 ft x 39.8 ft x 27.8 ft)	21.8 m x 13.3 m x 8.5 m (71.5 ft x 43.5 ft x 27.8 ft)
Door Size	3.5 m x 3.0 m (11.5 ft x 9.8 ft)	3.5 m x 3.0 m (11.5 ft x 9.8 ft)	4.5 m x 3.5 m (14.8 ft x 11.5 ft)	4.5 m x 3.5 m (14.8 ft x 11.5 ft)	4.5 m x 3.5 m (14.8 ft x 11.5 ft)	6.5 m x 4.0 m (21.3 ft x 13.1 ft)
Test Volume	3.0 m diameter x 2.5 m high (9.8 ft x 8.2 ft)	3.0 m diameter x 2.5 m high (9.8 ft x 8.2 ft)	4.0 m diameter x 2.5 m high (13.1 ft x 8.2 ft)	4.0 m diameter x 3.0 m high (13.1 ft x 9.8 ft)	4.0 m diameter x 3.0 m high (13.1 ft x 9.8 ft)	6.0 m diameter x 3.5 m high (19.7 ft x 11.5 ft)
Absorber Treatment	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250	DSH-600, DSH-1250

E-Motor Test System Including Dynamometer

ETS-Lindgren provides the most diverse and flexible E-Motor solutions to meet an evolving and innovating market

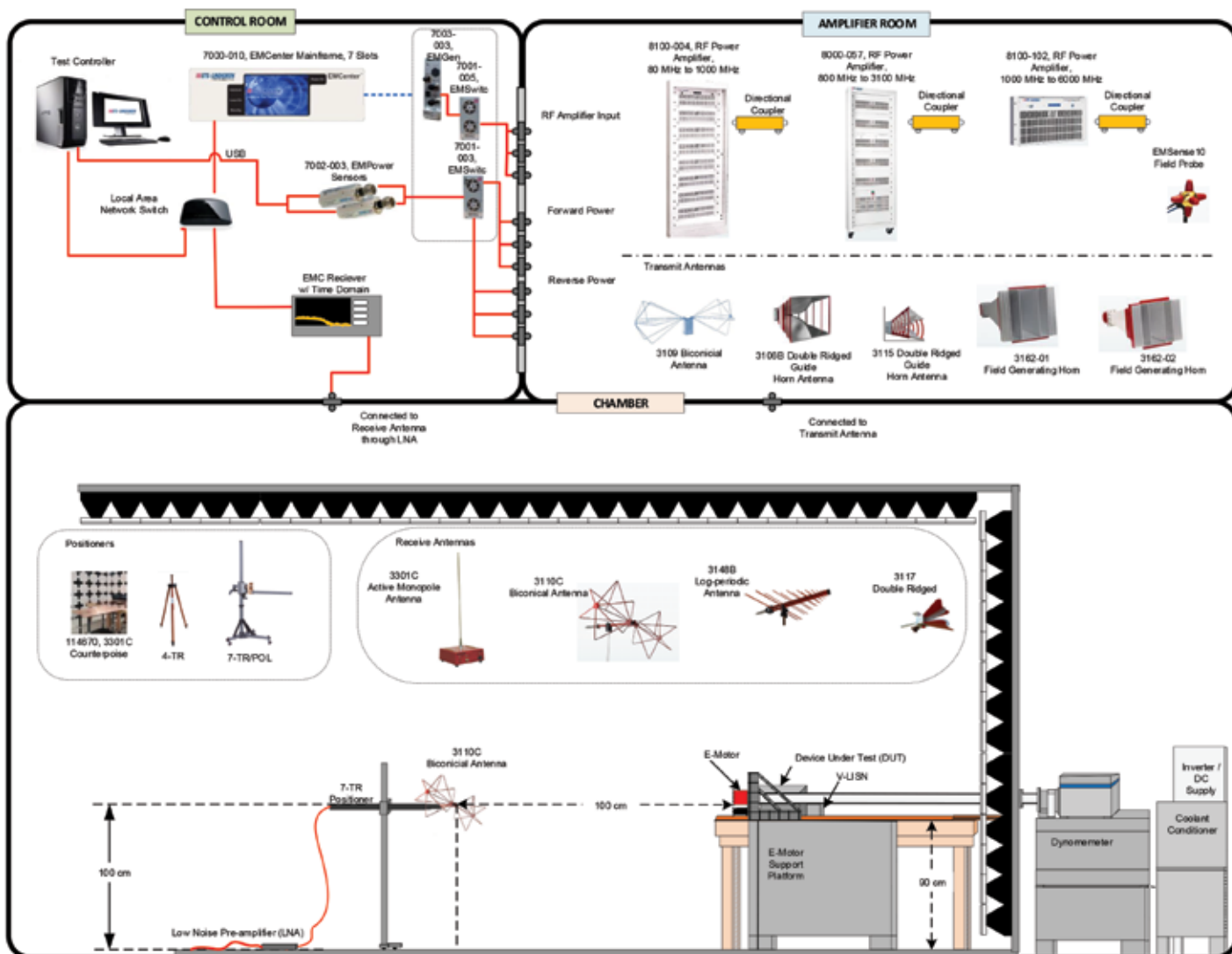
The EMC 3025-E E-Motor Test System differs from the standard EMC-3025 with the addition of the motor dynamometer, which acts as a load for the motor and inverter under test. Drive components typically operate at much higher voltages than the 12 V DC used in standard electronics, so additional precautions are needed to reduce the risk of electric shock. However, the primary difference between the EMC 3025-E and the EMC 3025 is the added motor dynamometer and its support equipment. These components allow the motor and inverter to be run under full load conditions in both the drive mode and regenerative braking mode. This simulates conditions during which the inverter is powering the motor, as well as when the inverter is charging the battery.

Standards

- Full Compliance Testing for Radiated Emissions:
 - CISPR 25
- Full Compliance Testing for Radiated Immunity:
 - ISO 11452-2
 - ISO 7637



E-Motor Test System with Dynamometer Layout



Chamber Specifications

Typical Specifications	EMC 3025-E
Chamber Size (Estimated Overall)	6.6 m x 6.2 m x 3.9 m (21.7 ft x 20.3 ft x 12.8 ft)
Chamber Size (Nominal Interior)	6.5 m x 6.0 m x 3.6 m (21.3 ft x 19.7 ft x 11.8 ft)
Door Size	1.2 m x 2.1 m (3.9 ft x 6.9 ft)
Test Volume (Typical)	0.5 m x 0.5 m x 0.2 m (1.6 ft x 1.6 ft x 0.7 ft)
Absorber Treatment	DSH-400

E-Axle Test System with Dynamometer

The EMC 3025-EX is another example of how ETS-Lindgren provides the most diverse and flexible E-Axle solutions to meet an evolving and innovating market

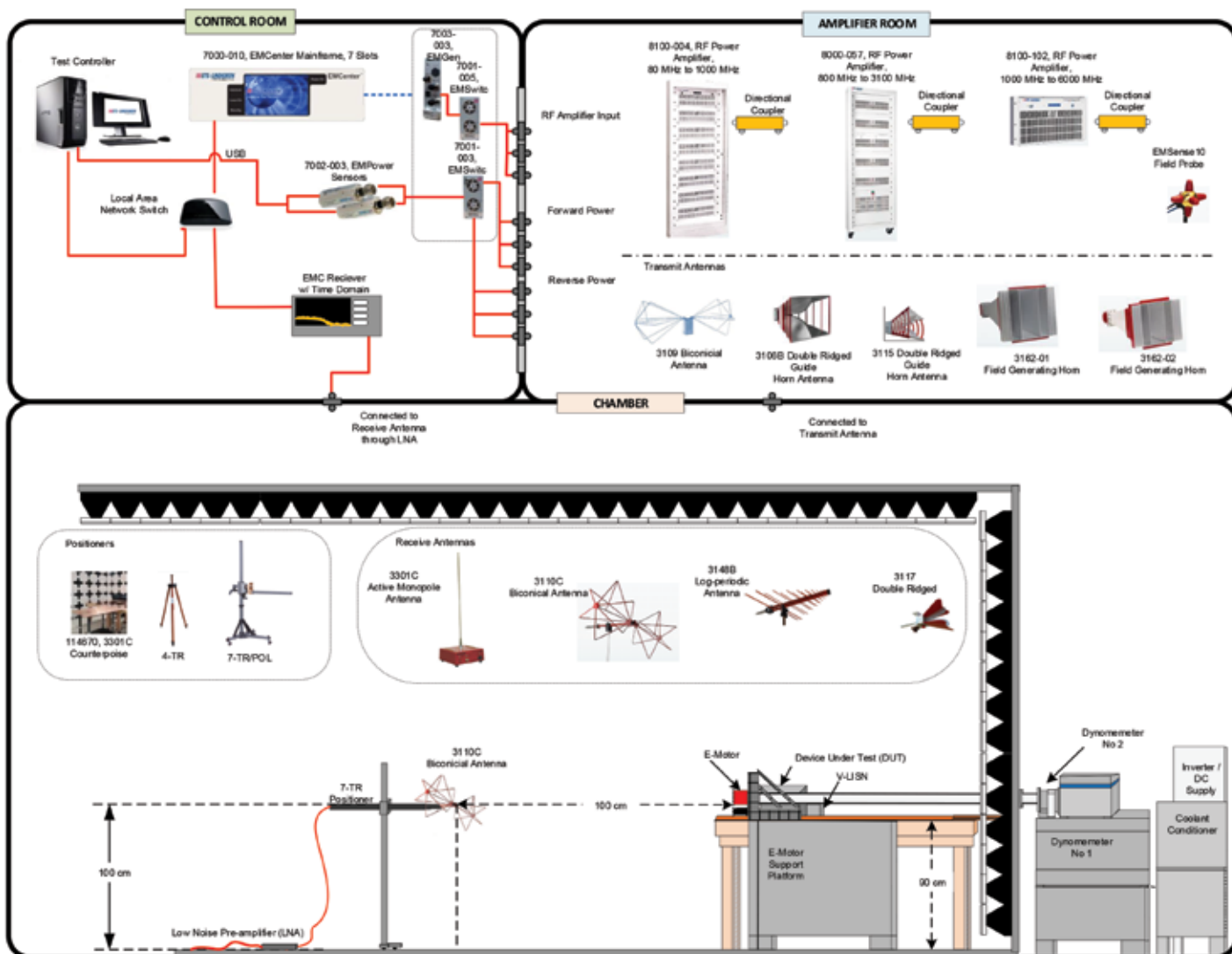
The EMC 3025-EX E-Axle Test System is a highly customized solution in which the overall chamber dimensions will be determined by the range of sizes and performance of the e-axle units to be accommodated. The primary separation requirements to the antennas and DUT remain the same, as do the test and measurement support instruments, but the mechanical support needed for the e-axle and the connecting bearings varies with the maximum speed and torque to be supported. E-axles are a variation of the separate e-motor drive designs seen in many first generation electric vehicles. In the latest development of the e-axle, the electric motor, transmission, and power electronics are all part of a single integrated unit with advantages in space saving, efficiency, cost, and performance. However, for EMC testing, the two output shafts provide an added complication, especially when additional controls are employed in the transmission. One solution: Use a dual-dynamometer setup to load the e-axle assembly. This solution provides for variable torque and speed with independent control for each shaft, thus remaining flexible and representative of real-world driving conditions.

Standards

- Full Compliance Testing for Radiated Emissions:
 - CISPR 25
- Full Compliance Testing for Radiated Immunity:
 - ISO 11452-2
 - ISO 7637



E-Axle Test System with Dynamometer Layout



Chamber Specifications

Typical Specifications	EMC 3025-EX
Chamber Size (Estimated Overall)	6.7 m x 6.3 m x 3.9 m (22.0 ft x 20.7 ft x 12.8 ft)
Chamber Size (Nominal Interior)	6.5 m x 6.2 m x 3.6 m (21.3 ft x 20.3 ft x 11.8 ft)
Door Size	2.1 m x 2.1 m (6.9 ft x 6.9 ft)
Test Volume (Typical)	1.0 m x 0.5 m x 0.5 m (3.3 ft x 1.6 ft x 1.6 ft)
Absorber Treatment	DSH-600

Fixed vs. Mobile Dynamometer

Finding the best dynamometer for your requirements

Fixed and mobile dynamometers each have specific pros and cons in respect to chamber installation and usage. ETS-Lindgren's fixed dynamometer solution includes fixed or custom chamber sizes to accommodate the maximum sized DUT with a dyno to support the maximum drive capacity. The fixed dyno solution can be configured for one or more dynos to support a configuration of e-drives. While the fixed solution provides a high degree of flexibility, it may also require more space outside the chamber to accommodate DC emulators and coolant conditioner as well as represent a more complex testing platform. The experts at ETS-Lindgren are here to support you through every aspect of the design process.

Our mobile dyno option allows customers to increase the capabilities of new or existing EMC chambers. The mobile dyno solution, with built in inverter drives and conditioning, can be configured for full vehicle and component testing with an easy conversion for a module test setup. While the mobile dyno solution requires setup during change over and is limited on maximum speed and torque, it is an innovative solution for those looking to maximize the capabilities of new or existing assets. See the tables below for a complete breakdown of the pros and cons of ETS-Lindgren fixed and mobile dyno solutions.

Fixed Installation vs. Mobile Dyno

Fixed Installation

Pros	Cons
Standard or custom sized chamber to match maximum DUT	Larger than minimum sized chamber for CISPR 25/ISO 11452-2 tests required
Dyno and support cabinets to match maximum drive capacity permanently installed	Limited to maximum capacity
Fixed stable supports for maximum speed and torque	Modified installation and supports needed
One or more dynos can be permanently installed for different e-drive configurations	Custom chamber design needed for e-axle configurations
Fixed or adjustable height / mounting of e-motor	Potentially larger, more complex platform required
Increased flexibility in test capability and capacity	Potentially higher in cost than mobile upgrade option in an existing chamber
All required inverter drives and conditioning units permanently installed outside the chamber	Additional space needed outside the chamber for drive cabinet, DC emulator, and coolant conditioner
Higher field levels can be accommodated inside the chamber	

Mobile Dyno

Pros	Cons
Full sized chamber available for full vehicle or component testing	Only module testing or full vehicle testing can be accommodated at one time
Easy changeover for module test setup	Setup time needed for changeover
Unit selection based on required capacity	Limited maximum speed and torque
Cables can be permanently routed below floor	Added access to cable connection points needed
Easily movable	Pallet truck or forklift needed for movement
Potentially lower mobile upgrade cost than fixed installation	Limited flexibility in test capabilities
Built-in dyno inverter drives and conditioning	Capacity limited to installed components
Can be used on an optional turntable for R & D 360° measurements	
Can be used as upgrade in existing EMC chambers thanks to the narrow design (<1 m width)	

Fixed Motor Dyno Typical Configuration

Fixed Testbed for EMC on load testing of e-motor and inverter components

System Specifications

Item	Description
Load System	AVL DynoFORCE™, AVL DynoULTRA™
Power	Up to 700 kW
Speed	Up to 20,000 rpm with direct drive, > 20,000 rpm with gear box
Torque	Up to 4,500 Nm
Testbed Mechanics	UUT Mounting System Intermediate bearing, Shaft System including wall penetration
Battery Emulation	AVL E-Storage System, up to 1,000 kW, 1,200 V, 3,200 A
Coolant Conditioning System	20 kW, 50 kW
Automation and Control Software	AVL PUMA 2 E-Motor

Fixed Motor Dyno

AVL E-Motor TS™ EMC - fixed



Mobile Dyno Typical Configuration

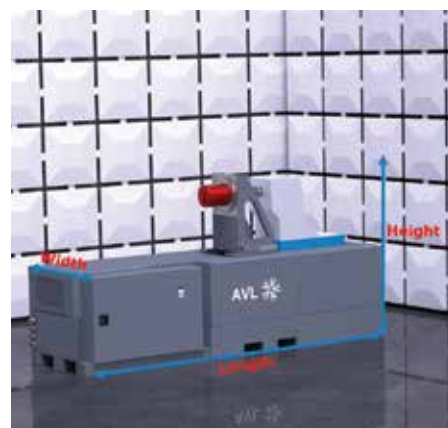
Mobile Testbed for EMC on load testing of e-motor and inverter components

System Specifications

Item	Description
Nominal Input Voltage (V)	380 to 480 AC 50/60 Hz
Nominal Input Current (A)	216
Maximum Speed (rpm)	15,000
Nominal Speed (rpm)	3,990
Nominal Torque S1 (Nm)	228
Overload Torque (Nm)	440 Nm at 440 V
Continuous Power, S1 (kW)	95
Overload Power (kW)	162 (60 s every 300 s, recovery load ≤ 90%)
Battery Emulation	AVL E-Storage System, up to 1,000 kW, 1,200 V, 3,200 A
Coolant Conditioning System	20 kW, 50 kW
Automation and Control Software	AVL PUMA 2 E-Motor

Mobile Dyno

AVL E-Motor TS™ EMC - mobile



Dimensions

Item	Description
Standard:	
Dyno Dimensions (Length x Width x Height)	2.4 m x 1.4 m x 1.6 m (7.87 ft x 4.59 ft x 5.25 ft)
Bench (Height)	0.821 m (2.69 ft)
Slim Line:	
Dyno Dimensions (Length x Width x Height)	3.3 m x 1.0 m x 1.6 m (10.83 ft x 3.28 ft x 5.25 ft)
Bench (Height)	0.821 m (2.69 ft)

EMC Parameters

Item	Description
Radiated Emissions	Frequency range 10 kHz to 18 GHz
Ground Noise	10 dB less than the CISPR 12 broadband transient emissions At least 10 dB better than class 5 according to CISPR 25 Ed. 4
Immunity Field	> 300 V/m

AVL E-Motor TS™ EMC - fixed, AVL E-Motor TS™ EMC - mobile, DynoFORCE™, and DynoULTRA™ are trademarks of AVL List GmbH.

SMART 80 Reverberation Test Chamber

Measurement frequency range: 80 MHz (10 kHz optional) to 18 GHz (40 GHz optional)

Full vehicle testing in a reverb environment

ETS-Lindgren's SMART (Statistical Mode Averaging Reverberation Test-Site)

Chambers use the latest developments in proven reverberation technology and experienced chamber design and construction, to create a suitable electromagnetic environment (EME) for immunity, emissions, and shielding effectiveness testing.

Compared with other test methods, SMART chambers offer the advantages of lower cost, higher field-to-input power ratios, and the ability to accept large test systems.

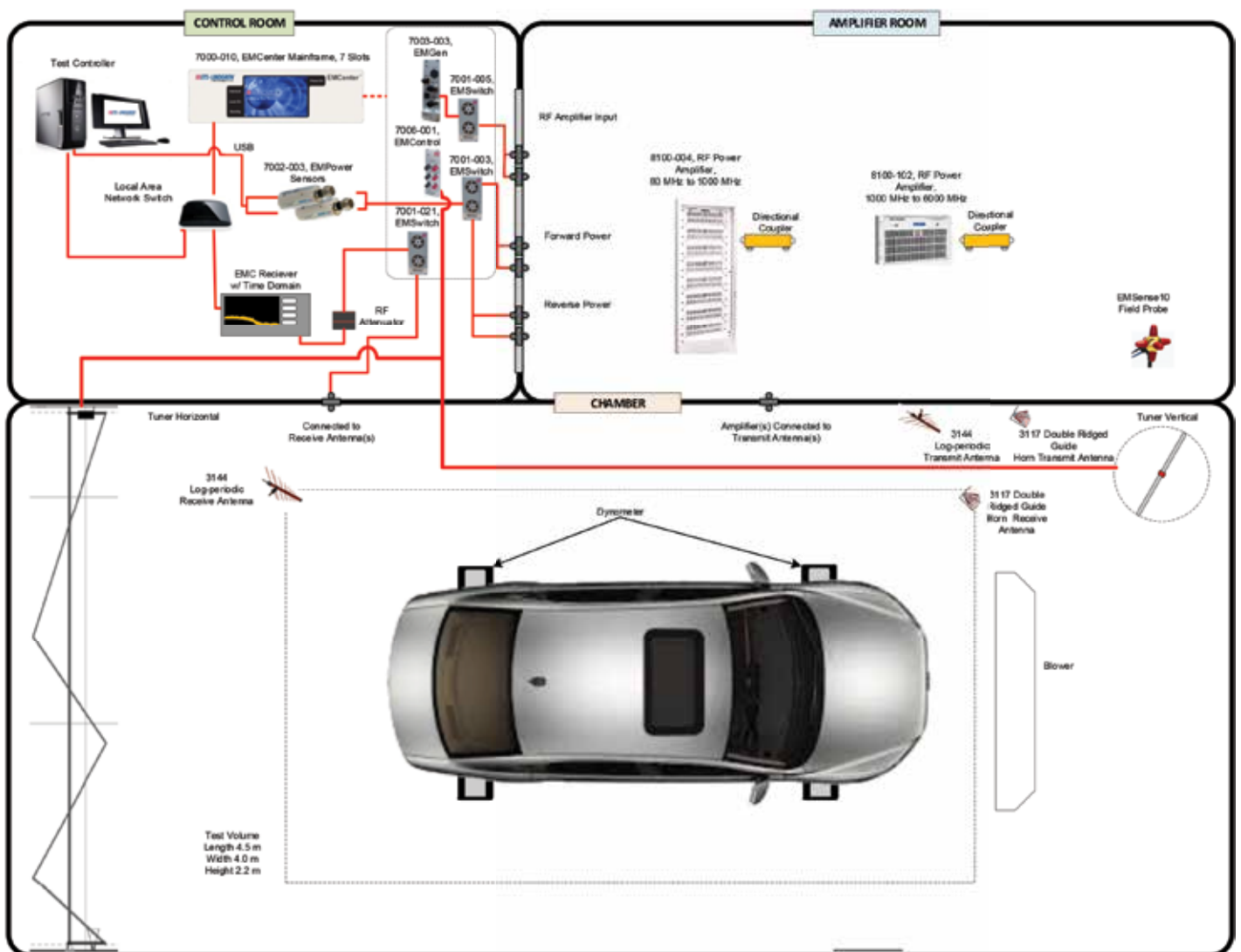
SMART chambers operate by using their interior surfaces to reflect internally radiated RF energy. One or more rotating paddles, or tuners, are used to change the cavity boundary conditions during the course of the measurement. This creates fields having statistical isotropy and homogeneity over a large working volume. ETS-Lindgren's tuner design ensures fast settling times and maximum test throughput during mode tuning testing. As an alternative, higher measurement throughput can also be achieved using very fast tuner rotation speeds in stirred mode operation as defined in some of the recent standards. The most recent ISO 11451-5 standard also supports using the reverb chamber at frequencies below the normal lowest operating reverb frequency, using different RF injection methods. This increases the usability of the chamber with the ability to test from as low as 10 KHz with a consequential increase in measurement uncertainty.

Standards

- Full and Pre-Compliance Testing Including:
 - ISO 11451-5
 - MIL-STD-461G
 - SAE J1113/27
 - EUROCAE/RTCA DO-160F/G
 - IEC 61000-4-21
 - DEF STAN 5941



SMART 80 Chamber System Layout



Chamber Specifications

Typical Specifications	SMART 80
Chamber Size (Estimated Overall)	13.4 m x 6.1 m x 4.9 m (44.0 ft x 22.0 ft x 16.0 ft)
Chamber Size (Nominal Interior)	13.9 m x 6.7 m x 5.4 m (45.6 ft x 22.0 ft x 17.7 ft)
Door Size	4.5 m x 3.0 m (14.8 ft x 9.8 ft)
Test Volume	4.5 m x 4.0 m x 2.2 m (14.8 ft x 13.1 ft x 7.2 ft)

SMART 200 Reverberation Test Chamber

Measurement frequency range: 200 MHz to 18 GHz (40 GHz optional)

Excellent test and measurement reproducibility

The SMART 200 Reverberation Chamber has intrinsic properties of isotropy and homogeneity that provide several unique features for testing. Assuming proper configuration and a given uncertainty level, field measurement results will be the same regardless of where in the room they are taken with reconfiguration of the EUT having minimal effect on those measurements.

SMART chambers are well suited to simulate the complex EMC of cavities, such as computer rooms, medical equipment rooms, aircraft avionics bays, and vehicle engine compartments. A SMART chamber simulates all wave polarizations and incidence angles during a full test.

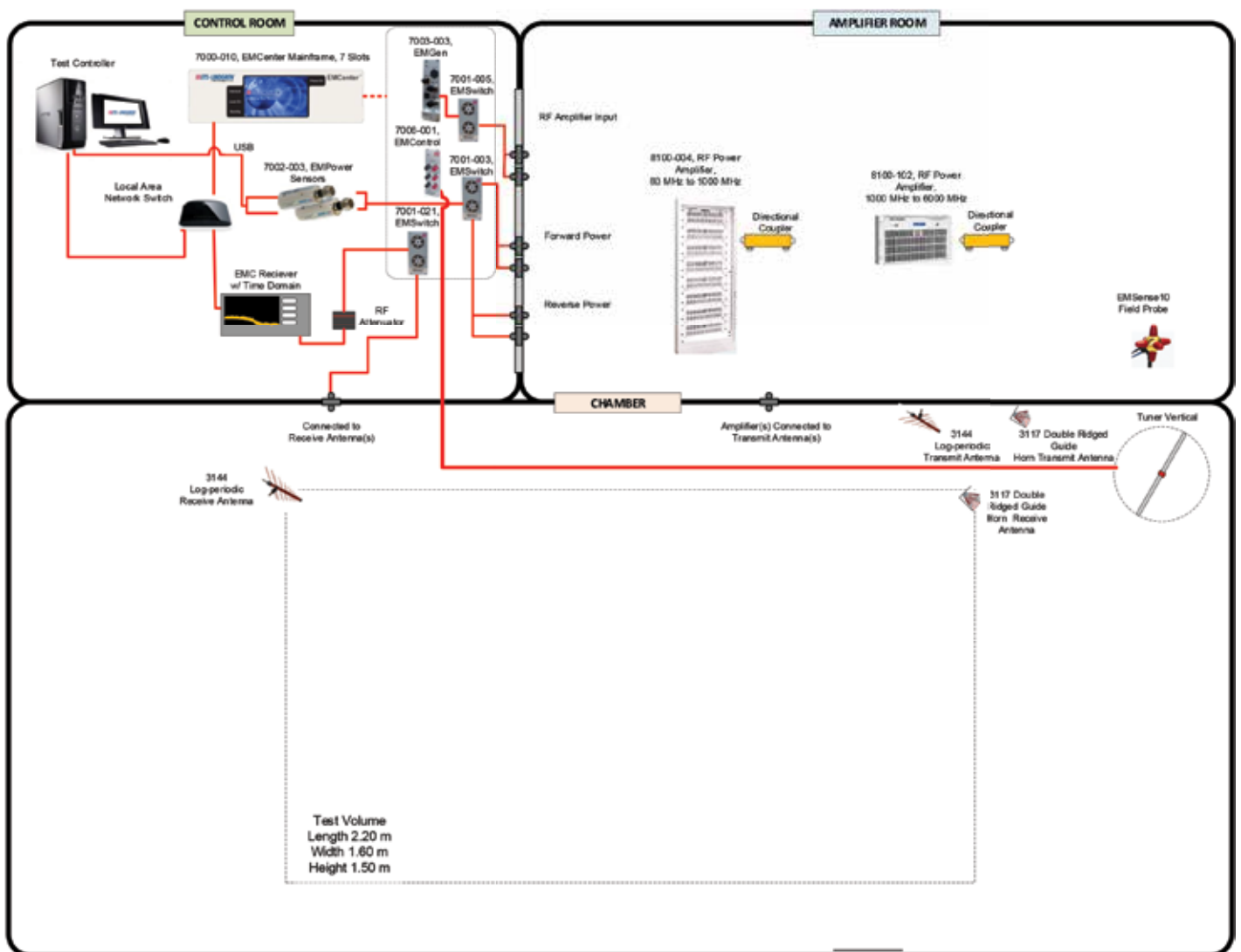
ETS-Lindgren understands reverberation chamber technology, and can design a chamber to meet your exact needs. We can work with you to determine the correct chamber volume for achieving the desired frequency range, select interior finishes to optimize mode density and Q-bandwidth, as well as recommend the right antenna and amplifier combination for field strength requirements.

Standards

- Full and Pre-Compliance Testing Including:
 - ISO 11452-11
 - MIL-STD-461G
 - SAE J1113/27
 - GMW3097
 - EUROCAE/RTCA DO 160F/G
 - FORD FMC 1278
 - IEC 61000-4-21



SMART 200 Chamber System Layout



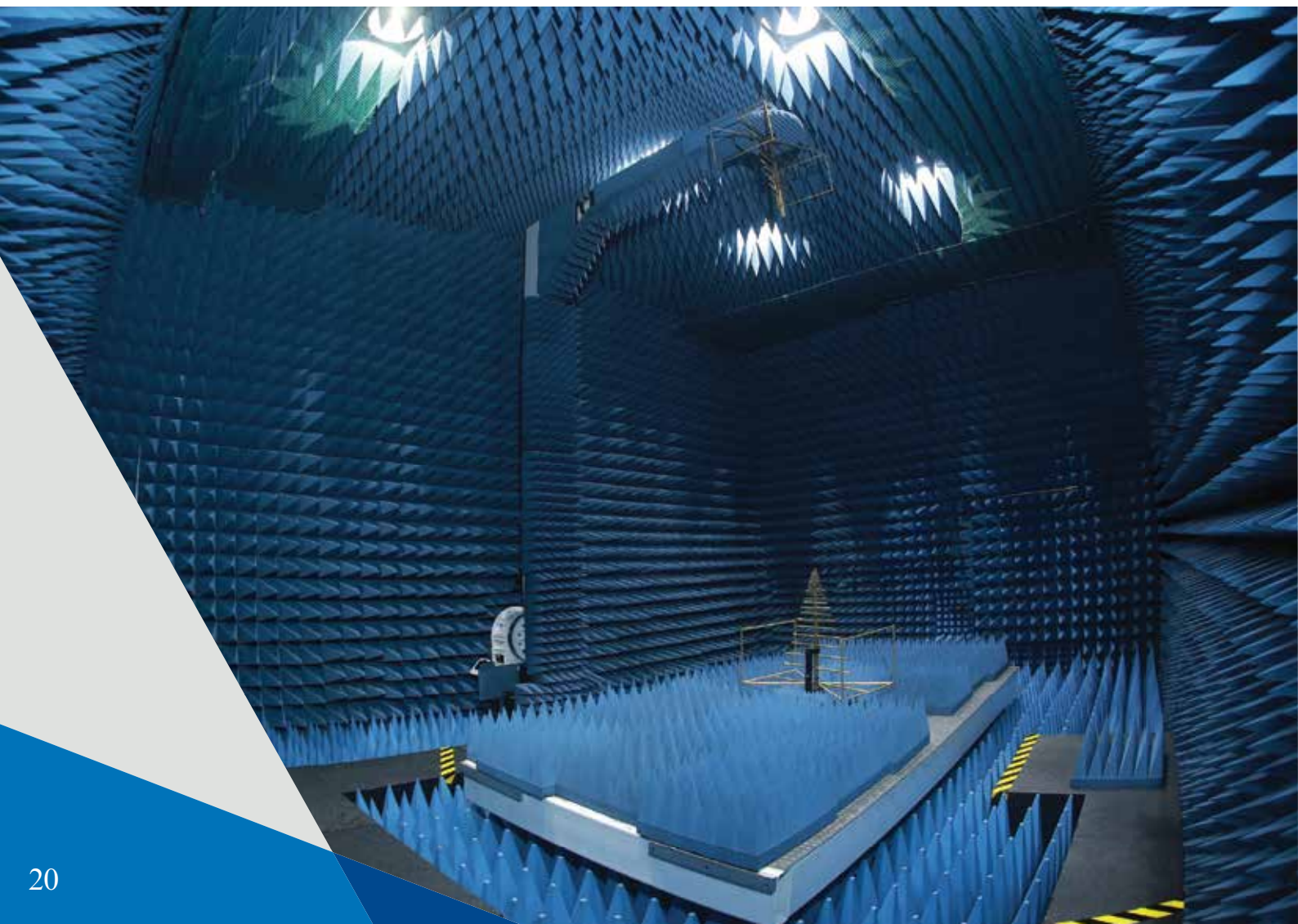
Chamber Specifications

Typical Specifications	SMART 200
Chamber Size (Estimated Overall)	5.0 m x 3.8 m x 3.3 m (16.4 ft x 12.5 ft x 10.8 ft)
Chamber Size (Nominal Interior)	4.8 m x 3.6 m x 3.1 m (15.7 ft x 11.8 ft x 3.3 ft)
Door Size	2.0 m x 2.0 m (6.6 ft x 6.6 ft)
Test Volume	2.2 m x 1.6 m x 1.5 m (7.2 ft x 5.3 ft x 4.9 ft)

WIRELESS ANTENNA PATTERN MEASUREMENT (APM) CHAMBERS

Antennas are everywhere on vehicles today, performing multiple tasks from basic communication to pedestrian detection and avoidance, to blind spot detection, to adaptive cruise control, to parking assistance, plus any other number of functions. It will not end there as manufacturers continue to explore future technologies including vehicle-to-vehicle (V2V) communication, vehicle-to-intelligent transportation systems (V2I), and vehicle-to-everything (V2X) communication. Understanding how these evolving technologies interact and co-exist is critical to successful implementation and product rollout.

ETS-Lindgren offers several solutions from vehicle antenna pattern measurement (APM) systems to our vehicle antenna measurement arch (VAMA) to meet your antenna measurement and characterization needs. At ETS-Lindgren, we also understand that not all testing requirements are created equally and with some of the smartest engineers in the industry, we are ready to assist you in developing custom test solutions to meet your specific needs.





ETS-Lindgren's APM Test Chambers include:

- Automotive APM Chamber
- Vehicle Antenna Measurement Arc (VAMA) Chamber

Furthermore, we recognize that not all testing requirements are the same. Our team is ready to collaborate with you in developing custom test solutions that align with your unique needs and challenges. With our expertise and industry-leading knowledge, we are committed to empowering you to integrate evolving antenna technologies.

As the automotive industry continues to evolve with advanced technologies, antennas remain at the forefront of innovation. ETS-Lindgren is dedicated to providing comprehensive solutions for antenna measurement and characterization, empowering you to seamlessly integrate evolving antenna technologies into your vehicles and drive the future of automotive excellence.

Automotive APM Test Chamber

Measurement frequency range: 70 MHz to 6 GHz

Antenna performance testing featuring a distributed axis positioner

ETS-Lindgren's Automotive Antenna Pattern Measurement (APM) Test Chamber is a theta arm based antenna measurement, ideally suited for automated measurement of antenna performance of wireless devices and devices with embedded wireless functions. This chamber features a distributed axis positioning system, consisting of an azimuth rotator to move the EUT about the phi axis and a separate theta arm positioner to elevate the measurement antenna around the EUT.

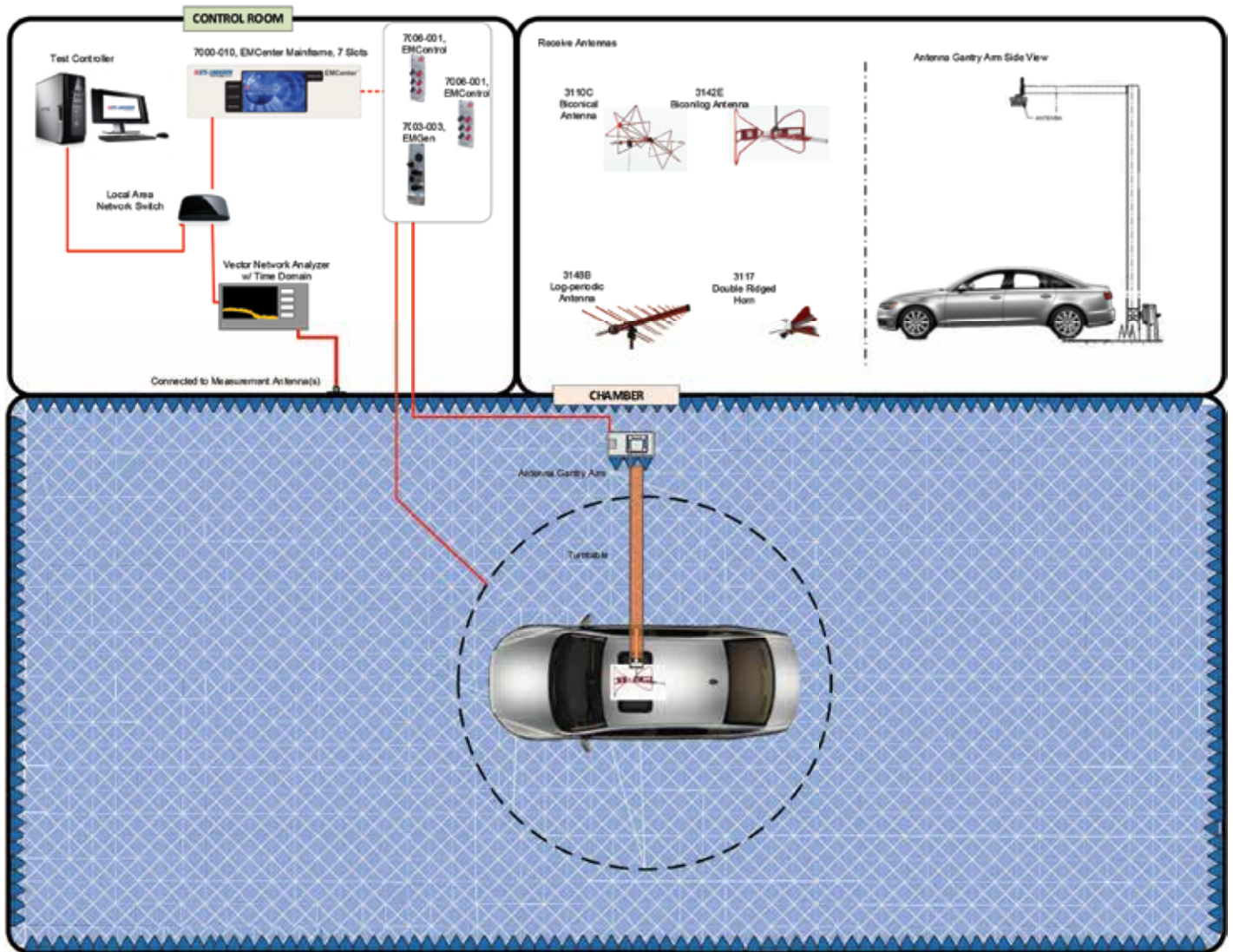
ETS-Lindgren's antenna measurement solutions cover a wide range of vehicle sizes and frequency bands. Chamber system designs are available for antenna pattern measurements from 70 MHz to 6 GHz for the standard communication bands, with options for extension to 40 GHz for 5G and 90 GHz for RADAR applications.

Measurement Types

- Gantry Arm
- Vehicle Antenna Measurement Arc (VAMA)
- Multi-sensor Arc



Automotive APM Chamber System Layout



Chamber Specifications

Typical Specifications	AMS-VAMA-G-300-300
Chamber Size (Estimated Overall)	10.9 m x 7.9 m x 7.3 m (35.6 ft x 26.0 ft x 24.0 ft)
Chamber Size (Nominal Interior)	10.7 m x 7.3 m x 6.3 m (34.0 ft x 24.0 ft x 20.7 ft)
Door Size	1.2 m x 1.2 m (3.9 ft x 6.8 ft)
Test Volume	5.0 m x 2.0 m x 1.2 m (16.4 ft x 6.6 ft x 4.9 ft)
Absorber Treatment	EHP-24PCL, EHP-24PCL WW

VAMA Test Chamber

Measurement frequency range: 400 MHz to 10 GHz

Antenna Pattern Measurements in a Compact Environment

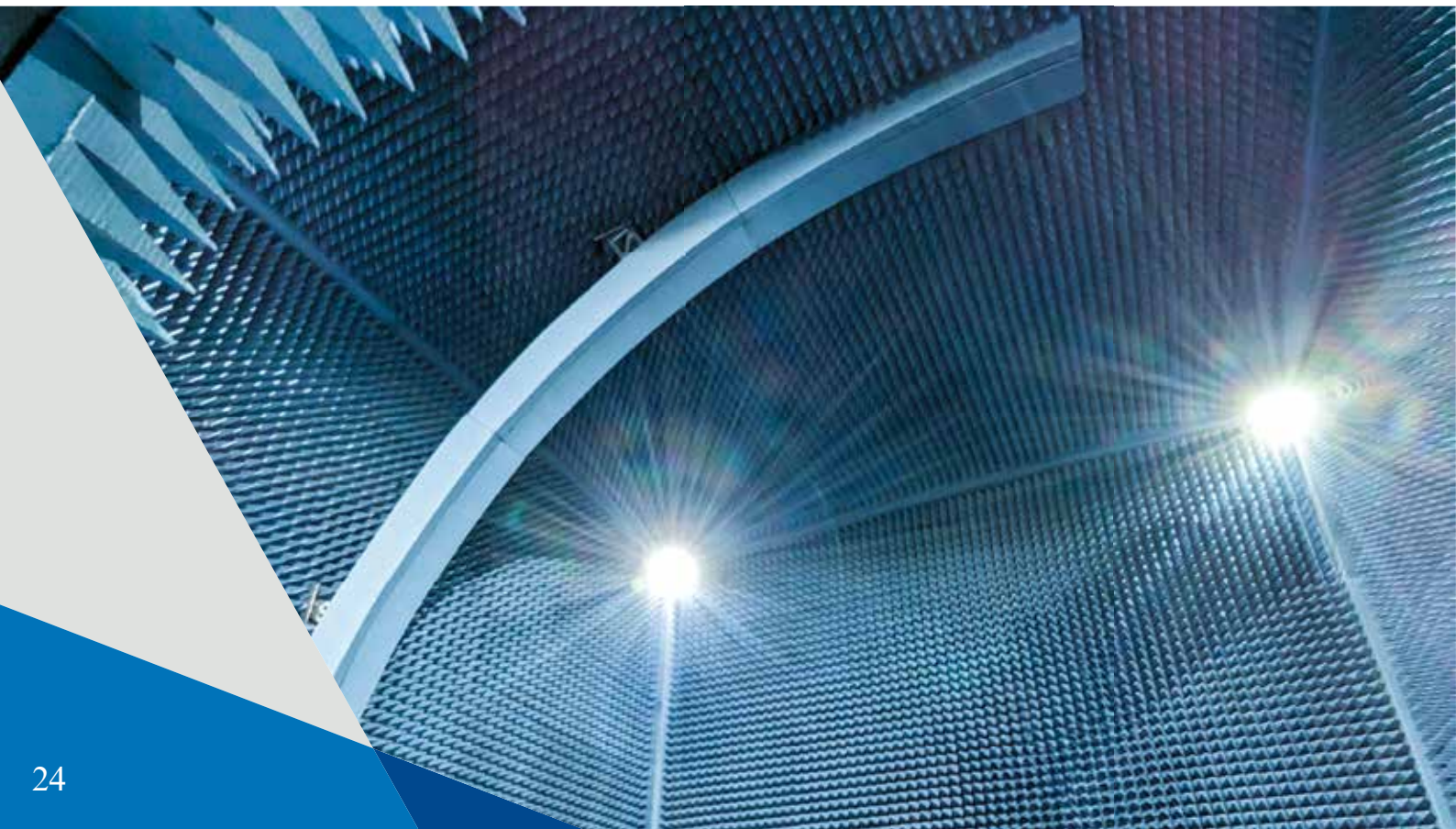
There are several accepted methods available for performing antenna pattern measurements at high frequencies. The measurement of large aperture antennas in the far field requires long-range lengths since ideally, the measurement should be made at a long enough distance to allow a relatively flat phase front (22.5 deg phase taper) across the aperture of the EUT. This may require a large chamber to meet the far field requirements. ETS-Lindgren's VAMA allows customers to collect data through near-field measurements in a more compact chamber.

ETS-Lindgren's VAMA is a fixed radius arch that allows the EUT to be mounted horizontally providing the ability to measure a partial sphere. Antennas are selected based upon the applications with considerations including measurement time and accuracy. The probe antenna moves over the upper hemisphere of the EUT collecting accurate near-field measurements of the magnitude and phase. A series of Fourier Transforms and probe antenna correction factors are applied as a function of orientation to derive the far-field antenna pattern.

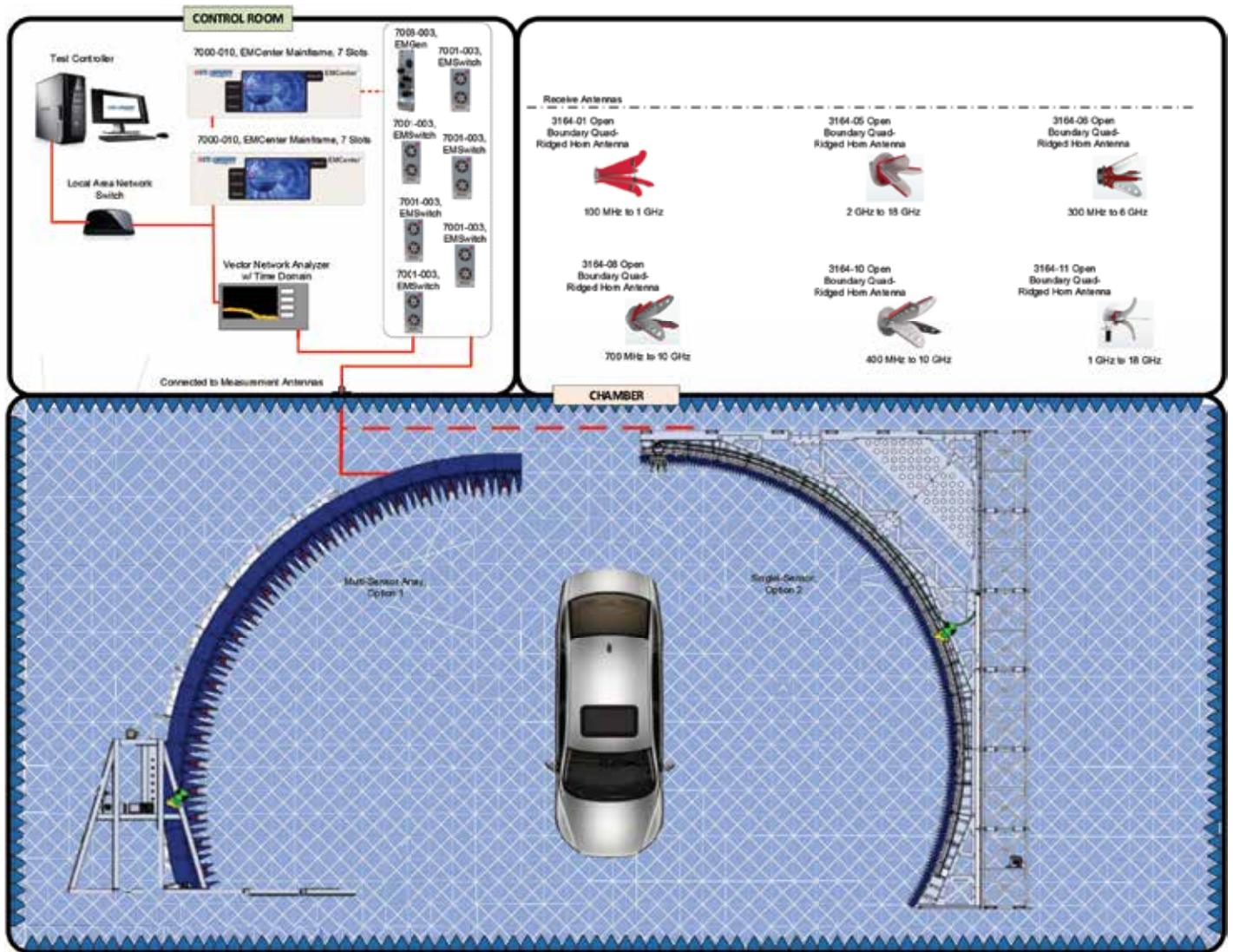
ETS-Lindgren's VAMA provides an intelligent innovative measurement technique to generating fast, accurate vehicle antenna pattern measurements in a more compact configuration.

Measurement Type

- Vehicle Antenna Measurement Arc (VAMA)



VAMA Chamber System Layout



Chamber Specifications

Typical Specifications	AMS-VAMA-R-600-600
Chamber Size (Estimated Overall)	14.5 m x 14.5 m x 10.6 m (47.6 ft x 47.6 ft x 34.8 ft)
Chamber Size (Nominal Interior)	14.0 m x 14.0 m x 10.0 m (45.9 ft x 45.9 ft x 32.8 ft)
Door Size	4.0 m x 3.5 m (13.1 ft x 11.5 ft)
Test Volume	4.3 m x 2.5 m x 1.5 m (14.1 ft x 8.2 ft x 4.9 ft)
Measurement Arch Radius	6.0 m (19.7 ft)
Absorber Treatment	EHP-12, EHP-24, EHP-36

ACOUSTIC CHAMBERS

When it comes to Noise, Vibration, and Harshness (NVH) acoustics, performance is paramount. At ETS-Lindgren, we understand the significance of achieving optimal results in various acoustic applications. Whether you're involved in developing noiseless products, mitigating interference from external noise and vibrations, creating impeccable conditions for sound recording and listening, ensuring precise audio measurements, or enhancing the performance of building materials, our wide range of acoustic products has got you covered. Each product is meticulously designed to address the specific requirements of NVH testing, reflecting our unwavering commitment to providing tailored solutions that align with your specific objectives.

At ETS-Lindgren, we prioritize precision and accuracy in our product design to ensure exceptional performance in the intended test application. We recognize that a standardized approach doesn't always suffice, which is why we offer a variety of sizes for our products. This flexibility allows you to select the dimensions that perfectly match your testing requirements, while also accommodating the specific conditions of your testing environment.





ETS-Lindgren's Acoustic Test Chambers include:

- Hemi-Anechoic Chambers
- Small Device (SD) Test Enclosures

With our extensive product line and customizable options, we are confident that ETS-Lindgren can provide customers like you with the ideal solution to meet your unique testing needs. Our dedication to delivering comprehensive choices ensures that you can achieve outstanding outcomes and project success. Place your trust in ETS-Lindgren to provide top-notch acoustic products that will take your testing endeavors to new heights. As the partner that consistently delivers the solutions you need, we are dedicated to delivering unparalleled performance.

Acoustic Hemi-Anechoic Test Chamber

Measurement frequency range (standard): 80 Hz to 20 kHz
Custom frequency ranges available

Precision- and engineering-grade acoustic test chamber

ETS-Lindgren's Hemi-Anechoic Test Chambers provide a precise free-field environment used to measure sound sources over a reflecting plane. Typical measurements include product noise testing, sound power, sound source frequency response, and sound source directivity. These chambers provide engineered features that achieve outstanding performance results and goals without compromising acoustical concepts and budgets. Hemi-Anechoic Test Chambers are used to perform precision- and engineering-grade testing on a wide variety of devices ranging from handheld units to large vehicles and equipment.

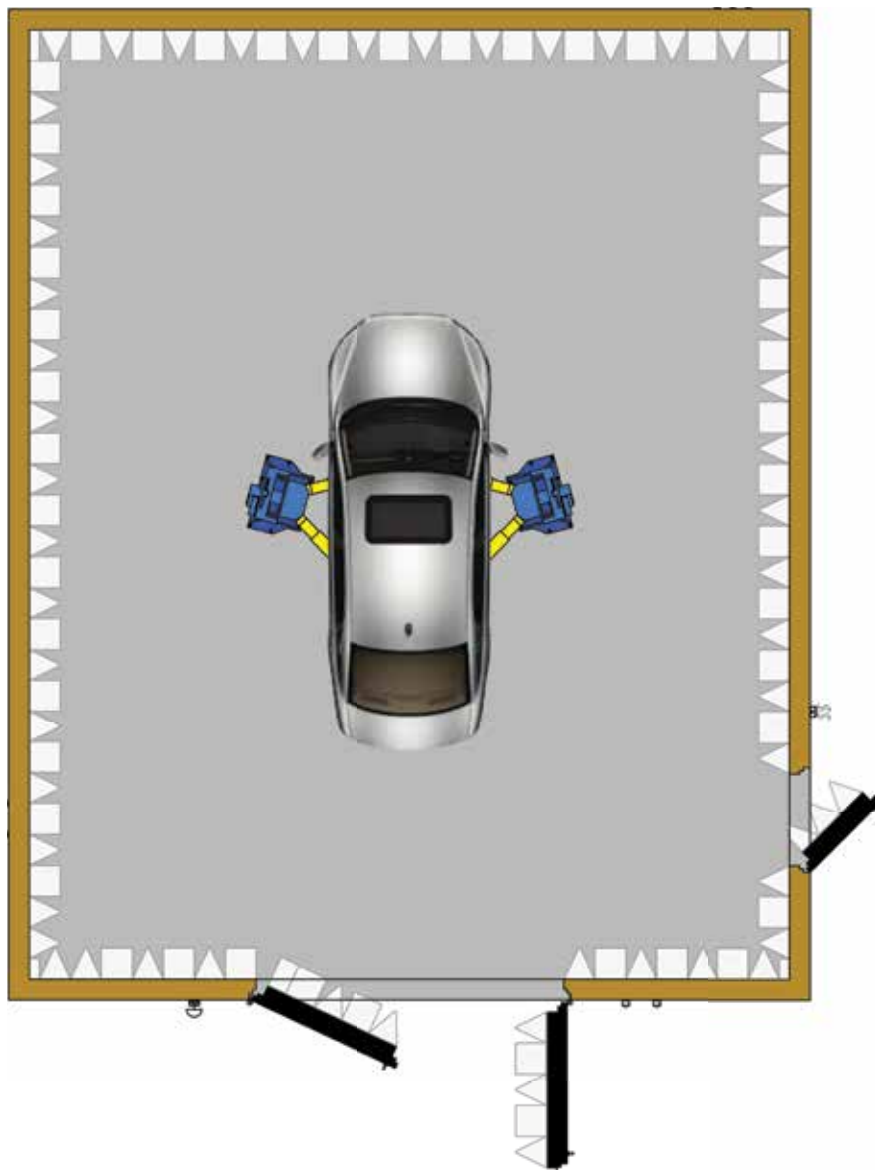
Hemi-Anechoic Test Chambers have a high performance wall panel system that provides the low-noise environment required to test today's low-noise products. A precision-grade free-field environment is the result of the Hemi-Anechoic Test Chamber's sound absorption system that consists of melamine wedges installed on a patented clip system that provides fast wedge installation and removal. Unlike other wedge solutions, melamine wedges provide a bright and fiber-free working environment. Custom chamber sizes are available.

Standards

- ISO 3744
- ISO 3745
- ISO 26101



Hemi-Anechoic Test Chamber Layout



Chamber Specifications

Typical Specifications	HA250-1.0	HA100-1.0	HA100-2.0	HA100-Vehicle
Chamber Size (Estimated Overall) ¹	4.1 m x 3.8 m x 2.9 m (13.3 ft x 12.3 ft x 9.6 ft)	5.6 m x 5.4 m x 4.7 m (18.5 ft x 17.8 ft x 15.3 ft)	8.3 m x 7.5 m x 5.3 m (27.1 ft x 24.5 ft x 17.3 ft)	8.3 m x 7.5 m x 5.3 m (27.1 ft x 24.5 ft x 17.3 ft)
Chamber Size (Nominal Interior)	3.1 m x 2.7 m x 2.1 m (10.0 ft x 9.0 ft x 7.0 ft)	4.1 m x 3.9 m x 3.7 m (13.3 ft x 12.7 ft x 12.0 ft)	6.7 m x 5.9 m x 4.3 m (22.0 ft x 19.3 ft x 14.0 ft)	6.7 m x 5.9 m x 4.3 m (22.0 ft x 19.3 ft x 14.0 ft)
Door Size	0.9 m x 2.1 m (3.0 ft x 7.0 ft)	0.9 m x 2.1 m (3.0 ft x 7.0 ft)	0.9 m x 2.1 m (3.0 ft x 7.0 ft) 2.4 m x 2.4 m (8.0 ft x 8.0 ft)	0.9 m x 2.1 m (3.0 ft x 7.0 ft) 3.1 m x 3.4 m (10.0 ft x 11.0 ft)
Standard Compliance of Free Field	250 Hz to 20 kHz to 1.0 m Hemisphere	100 Hz to 20 kHz to 1.0 m Hemisphere	100 Hz to 20 kHz to 2.0 m Hemisphere	100 Hz to 20 kHz to 1.5 m Hemisphere 80 Hz to 20 kHz 7.9 m x 2.6 m x 3.3 m (25.9 ft x 8.5 ft x 10.8 ft) Parallelepiped
Absorber Treatment	Melamine Wedges	Melamine Wedges	Melamine Wedges	Melamine Wedges

¹ Excluding Ventilation Silencers

Small Device (SD) Test Enclosures

Measurement frequency range (standard): 80 Hz to 20 kHz
Custom frequency ranges available

A free field environment for making survey and engineering grade measurements on small devices

ETS-Lindgren's Small Device Test Enclosures are acoustic chambers which provide a free field environment for making survey and engineering grade measurements on small devices. SD Test Enclosures are an affordable option when precision grade testing is not required, including acoustic testing for (sound power, sound pressure) levels of automotive components, computer hard drives, fans, pumps, and small mechanical and electric assemblies.

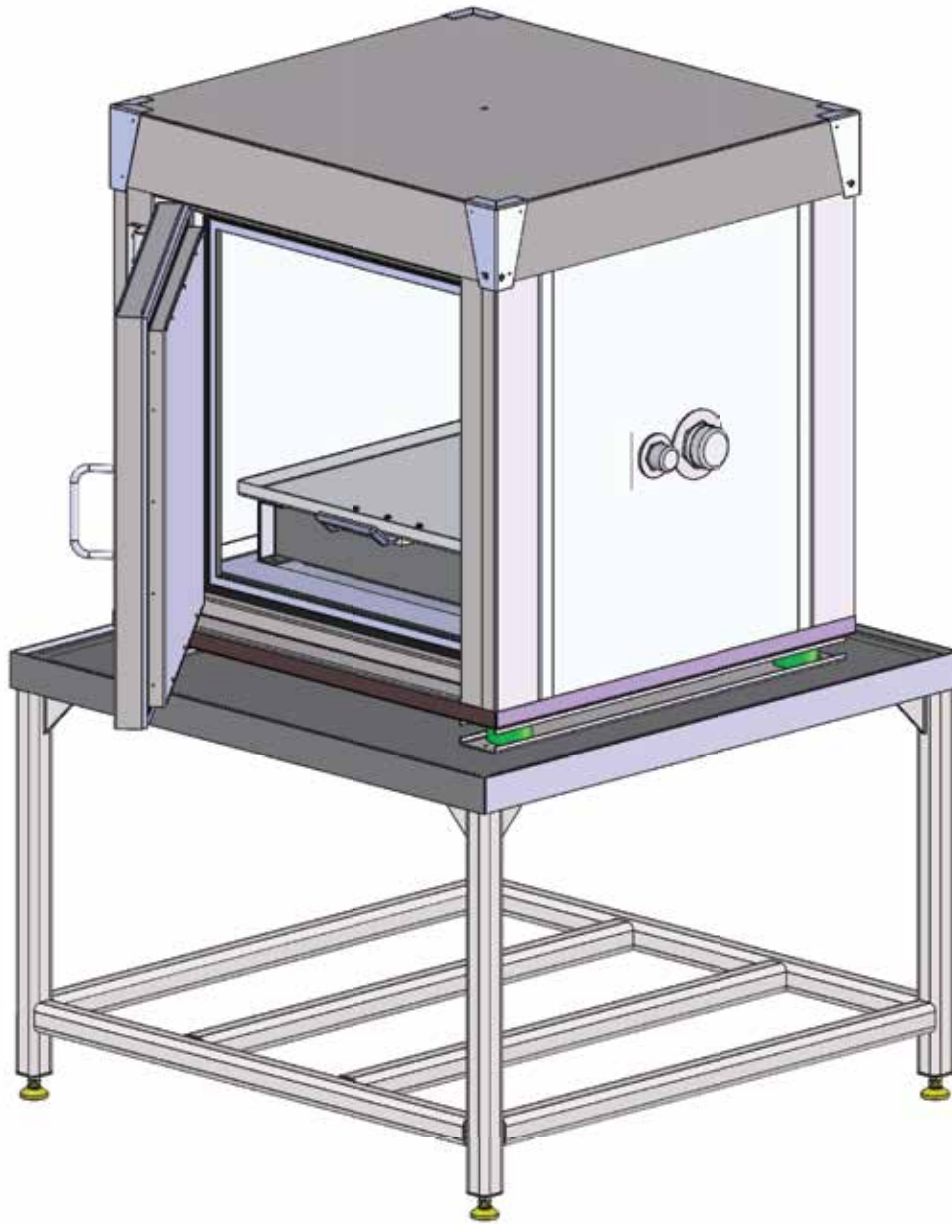
Testing can be conducted using either a single microphone, or a small array of microphones. SD Test Enclosures can also be used with vibration test equipment when required. Four sizes of SD Test Enclosures are available to accommodate most small test objects.

Standards

- Acoustical Testing:
 - ISO 3746
 - ISO 532B
 - ISO 11201
 - GM W7293 ISPR 25



Small Device Test Enclosure Layout



Enclosure Specifications

Typical Specifications	SD	SD1	SD2	SD3
Enclosure Size (Estimated Overall)	91.4 cm x 86.4 cm x 91.4 cm (36 in x 34 in x 36 in)	111.8 cm x 111.8 cm x 111.8 cm (44 in x 44 in x 44 in)	152.4 cm x 152.4 cm x 162.6 cm (60 in x 60 in x 64 in)	127 cm x 127 cm x 241.3 cm (50 in x 50 in x 95 in)
Enclosure Size (Nominal Interior)	71.1 cm x 66.0 cm x 71.1 cm (28 in x 26 in x 28 in)	91.4 cm x 91.4 cm x 91.4 cm (36 in x 36 in x 36 in)	121.9 cm x 121.9 cm x 132.1 cm (48 in x 48 in x 52 in)	106.7 cm x 106.7 cm x 213.4 cm (42 in x 42 in x 84 in)
Door Size	61.0 cm x 50.8 cm (24 in x 20 in)	61.0 cm x 61.0 cm (24 in x 24 in)	91.4 cm x 91.4 cm (36 in x 36 in)	81.3 cm x 203.2 cm (32 in x 80 in)
Absorber Treatment (Optional)	Melamine Wedges	Melamine Wedges	Melamine Wedges	Melamine Wedges

COMPONENT SOLUTIONS

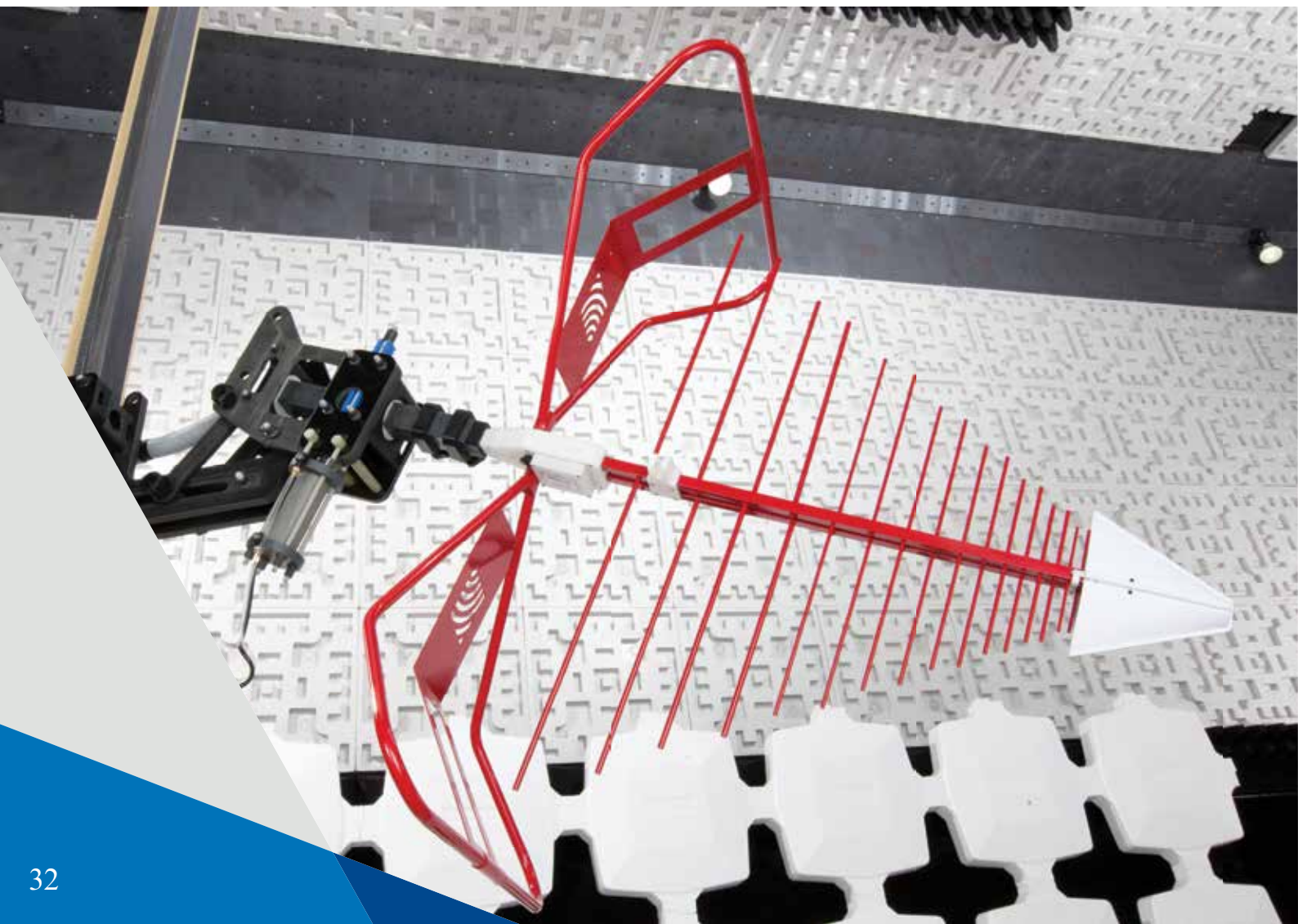
While ETS-Lindgren has a comprehensive offering of automotive test solutions, we also produce all the components required to facilitate your testing needs. ETS-Lindgren manufactures an array of absorber, probes, antennas, and positioners to meet your test applications. Do you have a unique requirement and cannot find an antenna or positioner to meet your needs? The experts at ETS-Lindgren can engineer a custom solution to accommodate your needs.

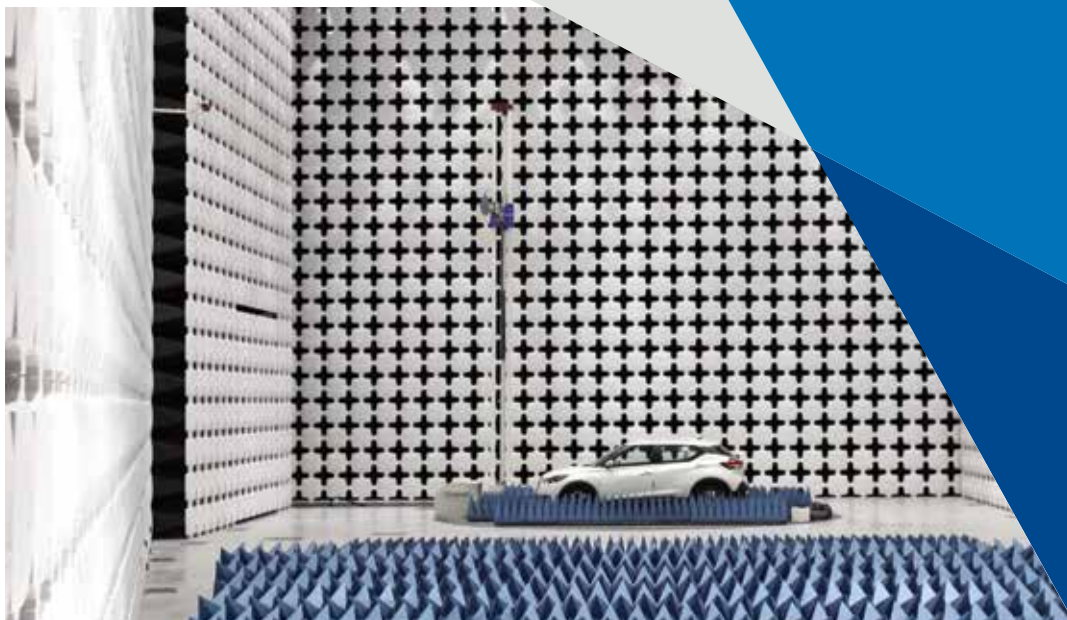
In addition to testing components, ETS-Lindgren offers a wide array of monitors and controllers to facilitate fast, accurate measurements. ETS-Lindgren provides meters, switches, controllers, and EMCenter™, which integrates the complete test system.

If you are looking to upgrade your components or increase the capabilities of your chamber, ETS-Lindgren has the components you need.

ETS-Lindgren's Test Components include:

- Antennas
- Positioners
- Probes and Monitors
- Absorber





ANTENNAS

ETS-Lindgren's antennas are designed with the latest computational modeling tools, manufactured with exacting precision, and individually tested, characterized, and/or calibrated in our A2LA accredited lab. For automotive test and measurement, ETS-Lindgren offers a broad line of antennas. Notably, our horn, biconical, and log-periodic antennas provide the repeatability and performance critical for efficient immunity and emission measurements.

POSITIONERS

ETS-Lindgren manufactures tripods, antenna towers, turntables, and test tables ideal for automotive test applications. Designed with the latest test standards in mind, these positioning systems are durable, easy to operate, and low maintenance.

PROBES AND MONITORS

ETS-Lindgren's HI Series of broadband E-Field probes meet or exceed the requirements for automotive, MIL-STD and commercial EMC RF immunity standards. Much like ETS-Lindgren's line of antennas, our probes are designed with performance and repeatability in mind.

ABSORBER

ETS-Lindgren has the ability to create customized absorber with special formulations and physical geometries to meet unique requirements. Workstations running advanced numerical modeling software are used to develop the right solution, which is then prototyped and tested to confirm predicted results. Each piece of absorber is individually serialized to ensure quality control.

TEST SYSTEM SOLUTIONS

With ETS-Lindgren, you work alongside a single, accountable partner with a proven track record of success. The hardest thing about building an RF test system is – everything. That’s why we’ve lightened the load by doing the heavy lifting for you.

Our integrated RF measurement solutions are specifically designed to meet the requirements of a particular test standard. They can include a complete turnkey system including the test environment (chamber, test cell, etc.) or just an integration of hardware and software for a chamber (or test cell) you may already have. With ETS-Lindgren, there’s no need to deal with multiple vendors or incompatible hardware issues. ETS-Lindgren is happy to integrate any manufacturer’s instrumentation into our test systems.

With us, you work with a single accountable partner with a proven track record of delivering on our commitments.





SOFTWARE SOLUTIONS

The backbone to ETS-Lindgren Systems is our software. Our software products are developed by professionals with the knowledge gained from designing, installing, and supporting EMC and Antenna Pattern Measurement projects.

ETS-Lindgren's award-winning Totally Integrated Laboratory Environment (TILE!™) software is simply the most powerful, yet flexible, EMC testing software – now specially enhanced for automotive, aerospace, and military applications. TILE! Software's simplified menu-driven interface with 3D graphics enables technicians to run an infinite number of test profiles for custom, RE/RI and CE/CI industry standards. The easy-to-use TILE! Test Executive feature provides test profiles with the ease of point-and-click menus, automating your EMC testing. With 1600+ drivers, TILE! supports most EMC instrumentation. TILE! also contains a powerful simulator tool enabling users to simulate tests, develop profiles, perform training, and provide customer demonstrations without leaving their desk, thus maximizing chamber utilization for testing applications.

ETS-Lindgren's VisionTRX™ Visual Monitoring System redefines automated movement based analysis of the EUT during EMC testing. In order to verify EUT behavior, the software allows automated visual monitoring of relevant parameters during exposure to the required electromagnetic field strengths. EUT may include speedometer needles, dash lights, LEDs, radios, heads up displays, etc. – the possibilities are endless.

This vision instrument can function either independently or seamlessly with ETS-Lindgren's TILE!, the powerful VisionTRX platform provides extensive time-saving capabilities with vast potential in your lab!



SERVICE SOLUTIONS

From education to consulting and product testing to calibration, ETS-Lindgren has dedicated experts committed to the success of our customers. ETS-Lindgren understands how downtime can impact our customers' development, production, and testing schedules. Let ETS-Lindgren assist in maintaining your chambers and training your employees to ensure optimal utilization of your assets.

ETS-Lindgren employs more than 750 professionals at locations in the Americas, Europe, the Middle East, and Asia. Our global network of independent representatives and distributors provide local service and support backed by the global resources of ETS-Lindgren.

Whether your chambers and shielding products are from ETS-Lindgren or another manufacturer, our experts can address your service needs. ETS-Lindgren is committed to meeting your service needs to minimize downtime and maximize your output.

ETS-Lindgren's services include:

- Field Services
- Calibration and Repair
- Engineering and Consulting
- Building Information Modeling (BIM)





FIELD SERVICES

ETS-Lindgren's Field Services provide a wide range of services related to electromagnetic compatibility (EMC), wireless, automotive, radio frequency (RF) microwave, and acoustic testing, as well as overall chamber and shielding maintenance. These services help businesses optimize the performance of their test and measurement equipment and shielding products, thereby improving testing accuracy, reducing the risk of costly errors, and maximizing operational throughput.

Within the EMC testing field, ETS-Lindgren offers services such as:

- NSA (Normalized Site Attenuation) Testing – measures the ability of a chamber to attenuate radio signals and evaluates the reflection level of the chamber quiet-zone for less than 1 GHz
- SVSWR (Site Voltage Standing Wave Ratio) Testing – evaluates the reflection level of a chamber quiet-zone for greater than 1 GHz measurement
- Field Uniformity Testing – measures the uniformity of the electric field in a measurement plane in a chamber
- Reverb Testing – evaluates the performance of chambers that will be used for EMC immunity, emission, and shielding effectiveness measurements, as well as those used for wireless device performance evaluation

Wireless Testing Services offered by ETS-Lindgren include testing for a variety of different wireless technologies, such as cellular handsets and base stations, Wi-Fi, Bluetooth, and many more. These services help businesses to ensure that their products meet regulatory requirements and perform optimally in a wireless environment.

In addition to testing services, ETS-Lindgren also provides Maintenance and Repair Services, including component repairs and replacements, turntable repairs, door repairs, and installation, as well as overall chamber maintenance. These services help extend the life of testing equipment while reducing the risk of costly downtime due to equipment failure. ETS-Lindgren's Technical Services Team is comprised of highly trained technicians with extensive experience in the field of EMC and RF testing. They have access to the latest test and measurement equipment and are committed to helping businesses optimize their testing processes and outcomes.

ETS-Lindgren also provides Shielding Services including shielding and door repairs, relocations, modifications, general maintenance, and shielding effectiveness testing. ETS-Lindgren can service and repair most shielding systems.

By providing a wide range of options, ETS-Lindgren's Field Services can help businesses save time and money while ensuring accuracy and reliability of chamber and shielding solutions.

CALIBRATION AND REPAIR SERVICES

At ETS-Lindgren, we take pride in providing Calibration and Repair Services of testing equipment for precise and consistent measurements every time. The company's calibration lab operates in accordance with ISO 17025 standards, assuring customers that their testing equipment is calibrated to a high degree of accuracy. Furthermore, our Calibration Services support a wide range of EMC and EMI testing equipment, from antennas and probes to GTEMs and receivers. Customers can choose from on-site or lab calibration services, with an electronic format signed certificate and correction factors (where applicable) provided for each calibrated item.

ETS-Lindgren operates an A2LA-accredited calibration laboratory (Lab Cert #1207.01) equipped with calibrated instrumentation traceable to global National Metrology Institutes (NMI). This calibration laboratory also houses several anechoic chambers, test cells, and a large 80 m x 50 m (262.47 ft x 164.04 ft) welded steel ground plane for antenna calibration. With this setup, ETS-Lindgren can calibrate all brands of EMC antennas and often make basic, pre-approved repairs. The services offered by the lab include repair of components including antennas, probes, and current clamps. ETS-Lindgren also offers the Calibration Service Plus™ program to assist our customers with their scheduling and budgeting needs.

On-Site Calibration Services

- Normalized Site Attenuation (NSA)
- Normalized Site Insertion Loss (NSIL)
- Site Voltage Standing Wave Ratio (SVSWR)
- Time Domain SVSWR
- Field Uniformity
- Quiet Zone Accuracy Testing
- Ripple Testing (CTIA)
- Shielding Effectiveness

Lab Calibration Services (including Repair Services)

- Antennas
- Field Probes
- LISNs
- Current Clamps

Don't see a calibration service you require? Contact your local ETS-Lindgren Representative for a customized services package.





ENGINEERING AND CONSULTING SERVICES

At ETS-Lindgren, we understand that each customer's needs are unique, and we strive to provide tailored solutions to meet those needs. Our range of Engineering and Consulting Services exemplifies this commitment to individualized service. We understand that time and money are critical considerations, so we work hard to deliver our services quickly and within budget.

We have in-house experts who specialize in designing integrated systems for EMC, wireless, acoustic, healthcare, security, general shielding, and audiometric applications. Our team can also design and manufacture custom components, ensuring that the customer receives the most intelligent and effective Solutions for their needs. In addition, we offer a variety of site surveys, including electromagnetic interference (EMI), vibration, and acoustic assessments, to provide information for planning purposes, pinpoint noise issues, and offer intelligently designed Solutions.

At ETS-Lindgren, we supply an assortment of design and site planning services. We have extensive experience in magnetic and shielding design, and collaborate with owners, architects, and contractors, assuring our Solutions seamlessly integrate into any construction project. Our design team understands the importance of controlling electromagnetic interference (EMI), radio frequency interference (RFI), sound, and vibration in sensitive settings, which is why we offer customized Solutions for each application. Finally, our Building Information Modeling (BIM) capabilities allow for precise planning of complex construction projects, reducing errors and rework.

Whether you need assistance designing a new wireless, EMC, or acoustic lab; state-of-the-art research facility; government installation; or healthcare imaging center, ETS-Lindgren is your trusted partner to achieve your design requirements and ensure you realize your objective.

BUILDING INFORMATION MODELING

Gain better insight and predictability of the physical facility – before it is built – with Building Information Modeling (BIM) from ETS-Lindgren. It not only provides 3D representations of the architecture, but also the mechanical, electrical, and plumbing. So, you're able to see how our recommendations about the RF shielded enclosure will interface with the overall building. It's a great collaborative tool that delivers the results you're looking for, including lower expense and risk, fewer construction delays and rework, and decreased on-site problems.



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