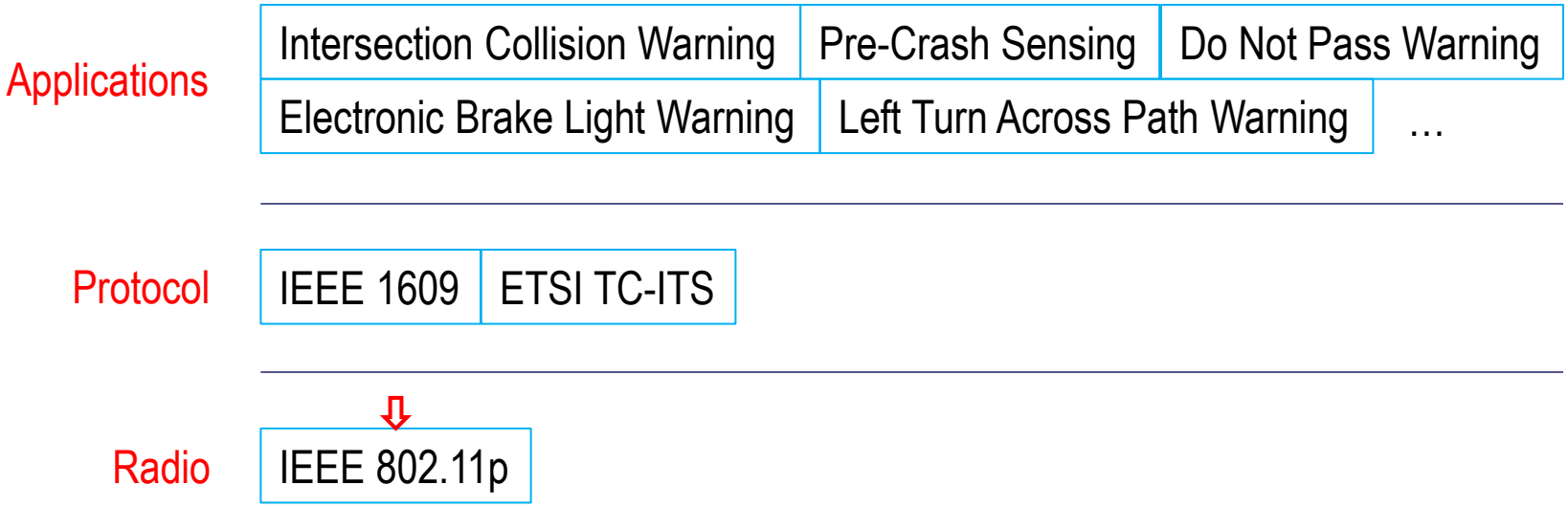
octoScope

DSRC Evaluation under Controlled Environment

20 February 2013

Fanny Mlinarsky
octoScope, Inc.
fm@octoscope.com

Big Picture



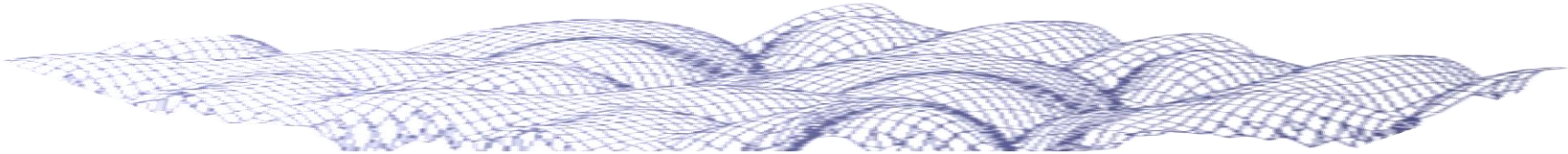
Radio layer is the foundation. Everything rests on the radio.

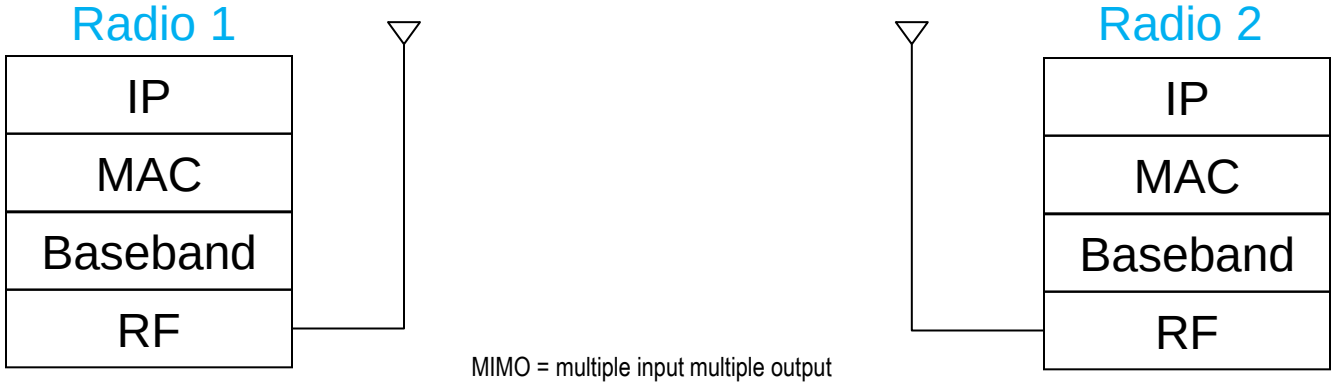
Contents

- Standards-based wireless test methods and metrics
- Challenges specific to DSRC radios
- Comparison of DSRC evaluation techniques
- Merits of controlled environment testing

Common Wireless Test Metrics

R&D	QA	Deployment
RX sensitivity TX spectrum Throughput vs. range Adaptive modulation MIMO modes Roaming, handover Mesh algorithms Throughput Delay Packet error rate	Test automation Regression testing Conformance Interoperability Regulatory compliance Reproducing field failures	Pre-deployment lab test Field survey Deployment test Monitoring





MIMO = multiple input multiple output
MAC = medium access control
IP = internet protocol

Wireless Test Standards

DSRC?

2G/3G/LTE	Wi-Fi	Data transport	Applications	Smart Grid
3GPP RAN5 →ETSI →PTCRB/GCF (conformance, interoperability) CTIA (TIS/TRP MIMO-OTA SAR)	Wi-Fi Alliance (WMM, WPA, etc.) IEEE 802.11.2 (range, throughput, latency)	IETF RFC 2285, 2544, 2889 (packet loss, latency, jitter)	ITU-T Voice Quality P.800 (MOS); P.862 (PESQ); G.107 (R-Factor) IETF video quality RFC 4445 (MDI MLR, DF)	NIST SEP 2 interoperability

3GPP = 3rd generation partnership project
RAN = radio access network
IETF = internet engineering task force
RFC = request for comments
GCF = global certification forum
ITU = international telecommunication union
ETSI = European Telecommunications Standards Institute
CTIA = cellular telecommunications internet association

TIS = total isotropic sensitivity
TRP = total radiated power
MIMO = multiple input multiple output
OTA = over the air
SAR = specific absorption ratio
WMM = wireless multimedia
WPA = wireless protected access

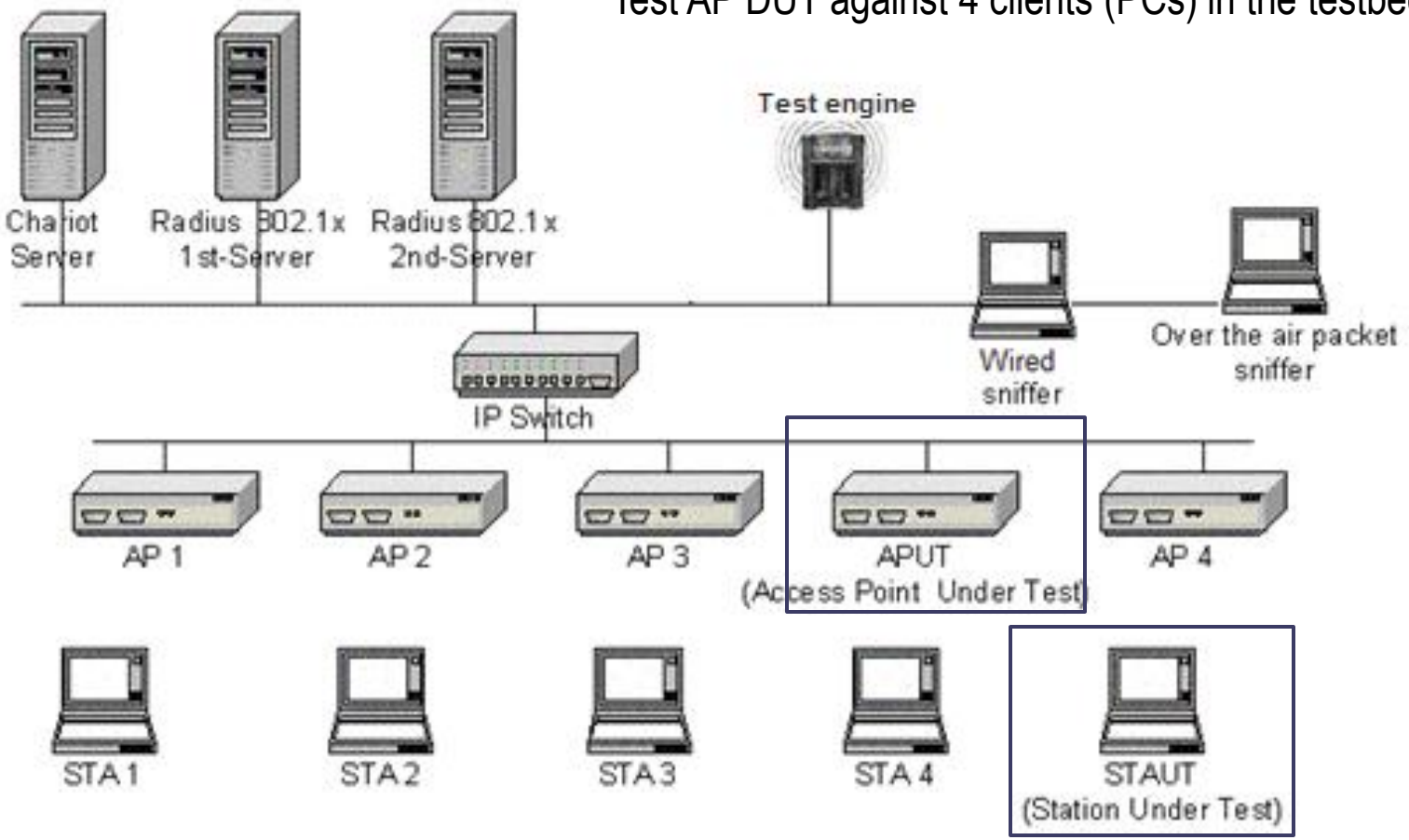
NIST = national institute of standard and technology
SEP = smart energy profile
MOS = mean opinion score
PESQ = perceptual speech quality measure
R-Factor = rating factor
MDI = Media Delivery Index
MLR = media loss rate
DF = delay factor

Wi-Fi Alliance Certification

- The Wi-Fi Alliance is a certification organization for the 802.11 industry
- Responsible for certification testbed, test standards
- Recently also created its own standard – Wi-Fi Direct – outside of the IEEE 802.11

Wi-Fi Alliance Testbed

Test a client DUT against 4 APs in the testbed
Test AP DUT against 4 clients (PCs) in the testbed

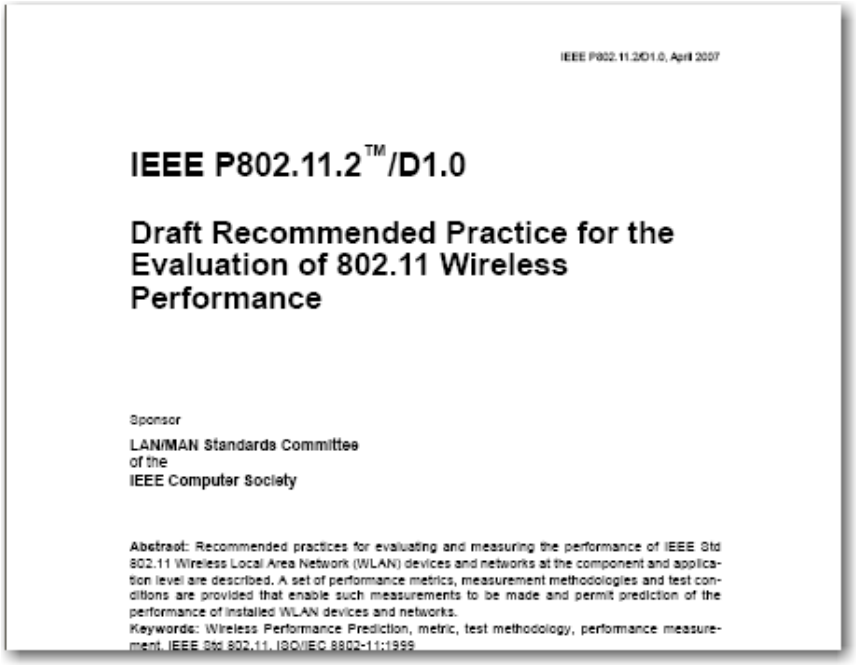


DUT = device under test

IEEE 802.11 Test Specification

IEEE 802.11.2, a recommended practices document, was developed by TGT

Defines methods and metrics for evaluating performance of 802.11 devices and systems



IEEE P802.11.2/D1.0, April 2007

IEEE P802.11.2™/D1.0

Draft Recommended Practice for the Evaluation of 802.11 Wireless Performance

Sponsor

LAN/MAN Standards Committee
of the
IEEE Computer Society

Abstract: Recommended practices for evaluating and measuring the performance of IEEE Std 802.11 Wireless Local Area Network (WLAN) devices and networks at the component and application level are described. A set of performance metrics, measurement methodologies and test conditions are provided that enable such measurements to be made and permit prediction of the performance of installed WLAN devices and networks.
Keywords: Wireless Performance Prediction, metric, test methodology, performance measurement, IEEE Std 802.11, ISO/IEC 8802-11:1999

Examples of 802.11.2 Test Metrics

- Unicast intra-BSS throughput
- Unicast ESS throughput
- Multicast forwarding rate
- Endstation association rate
- Endstation database capacity
- Power consumption
- Coexistence of overlapping BSSs in an OTA environment
- Packet loss
- Latency
- Jitter
- Video performance
- Throughput: overall
- Throughput vs. range
- Throughput vs. attenuation (conducted and OTA)
- Throughput vs. receive power
- Transmit rate adaptation
- Antenna diversity
- Adjacent channel interference
- BSS transition time
- Fast BSS transition time
- Receiver sensitivity in a conducted environment

BSS = basic service set

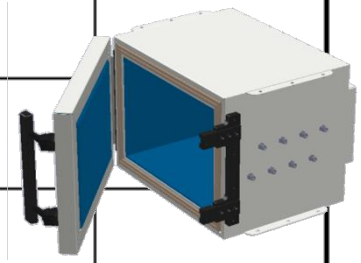
Test Environments per 802.11.2

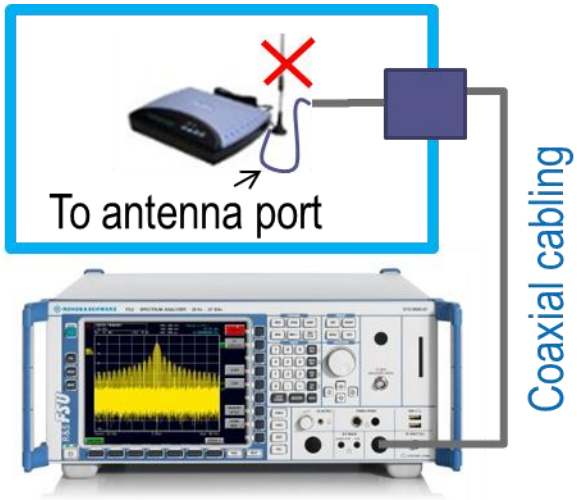
Controlled and uncontrolled environments

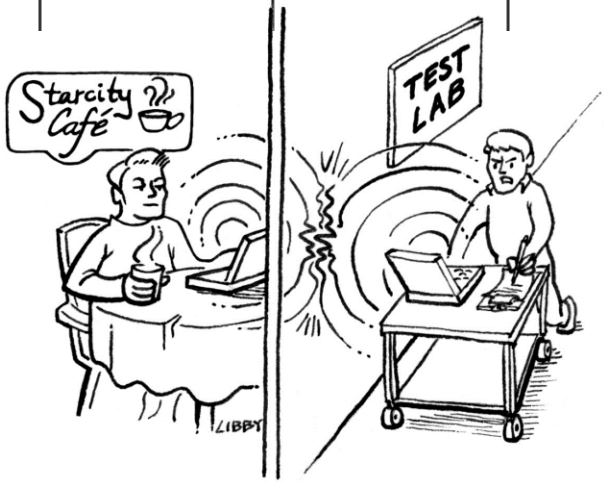
Table 1—Cross-reference of metrics and environments *(continued)*

Source: 802.11.2

Metric	Conducted test environment √	Calibrated over the air test (COAT) √	Over the air outdoor LOS	Over the air indoor NLOS	Over the air indoor LOS	Over the air shielded enclosure √
Transmit rate adaptation	Y					
Antenna diversity	Y					
Adjacent channel interference	Y					

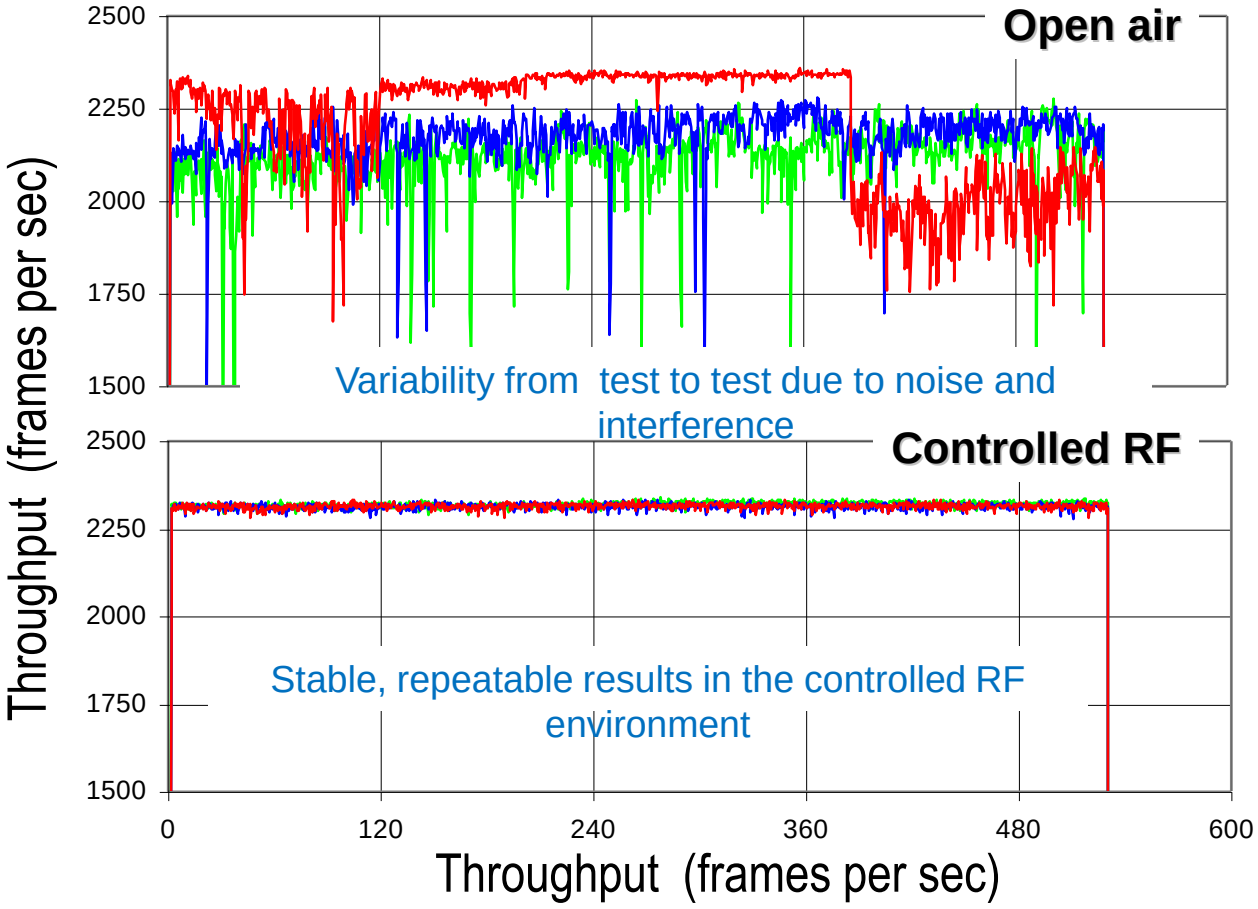


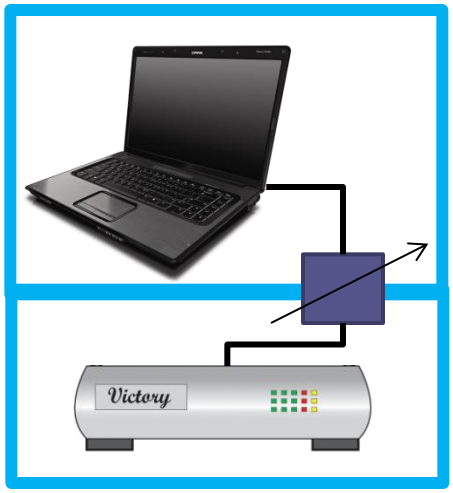




√ = controlled environment

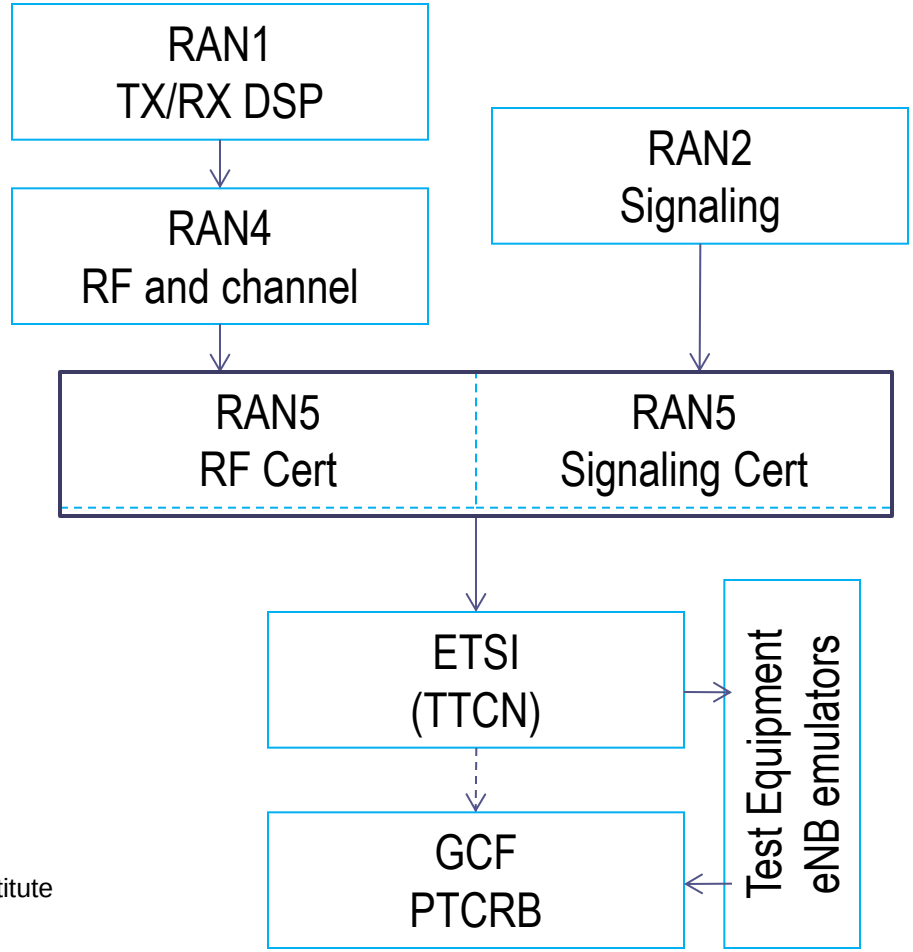
Open Air vs. Controlled RF Environment





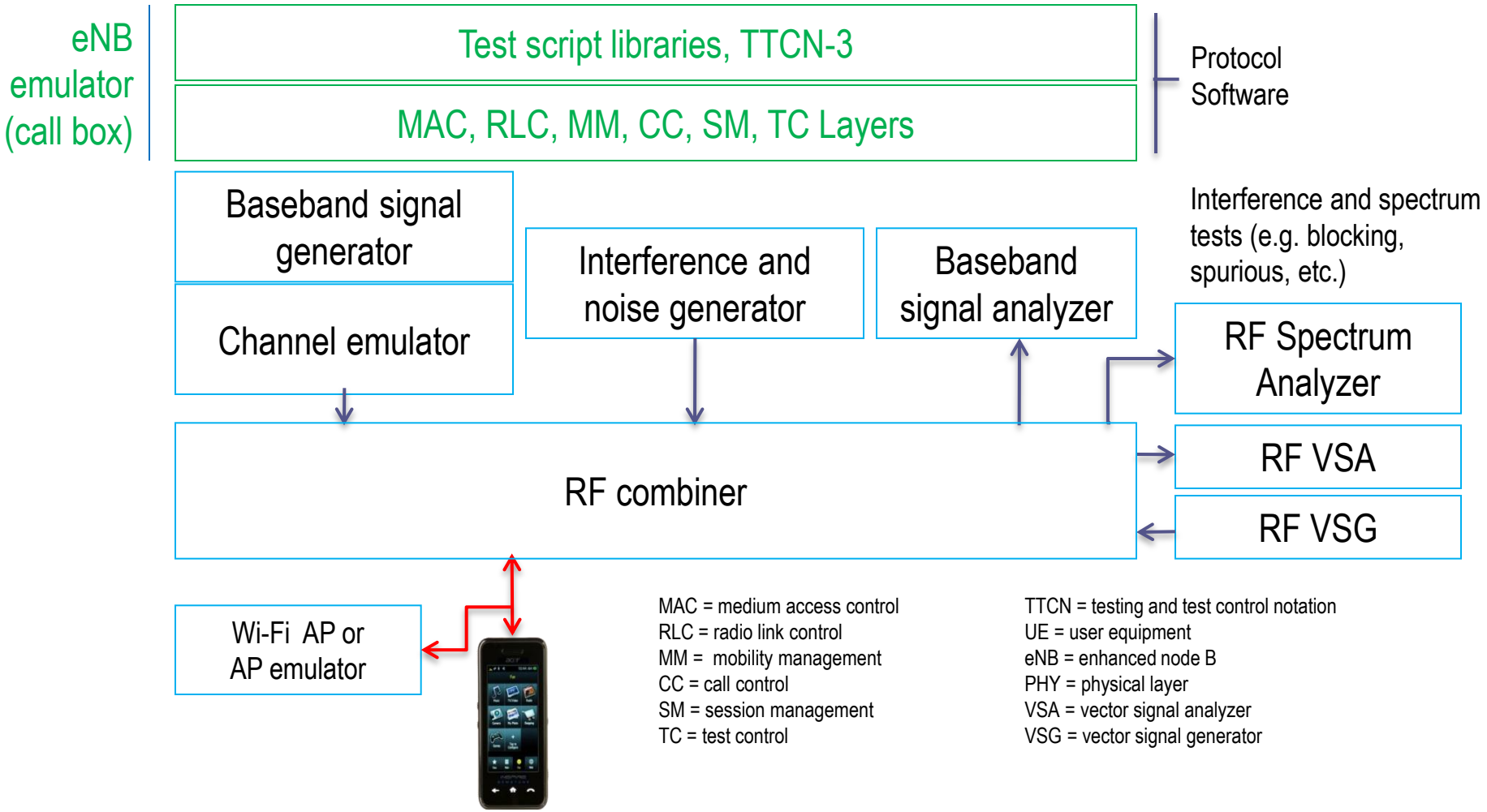
3GPP Test Standards Committees

- RAN1-4 develop the functionality standards
- RAN4 feeds RAN5 RF group with test requirements
- RAN2 feeds RAN5 Signaling group with test requirements
- ETSI develops TTCN code per RAN5 standards and makes code available as open source
- TTCN makes signaling certification uniform; RF certification is different among test equipment vendors



3GPP = 3rd generation partnership project
RAN = radio access network
GCF = global certification forum
ETSI = European Telecommunications Standards Institute
TTCN = Testing and Test Control Notation
Cert = certification

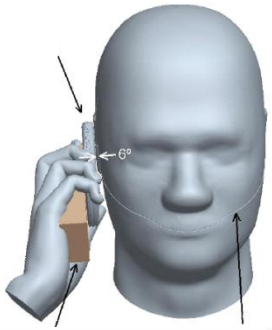
Certification Testbed for a Mobile Device

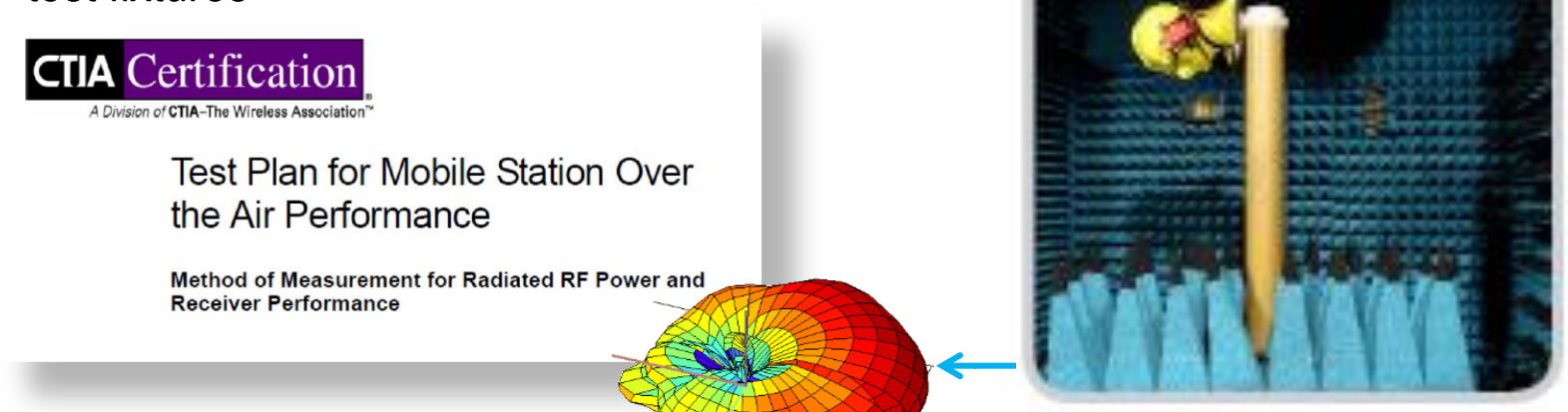


CTIA Certification – TIS/TRP

- CTIA certification includes TIS and TRP measurements
  - 3D RX and TX performance measurements
- Testing performed in an anechoic chamber
- Phantom head and hand sometimes used as test fixtures

Phone under test on a phantom head



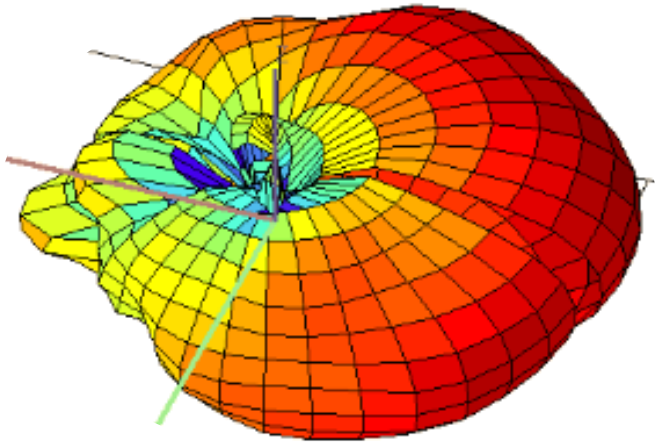


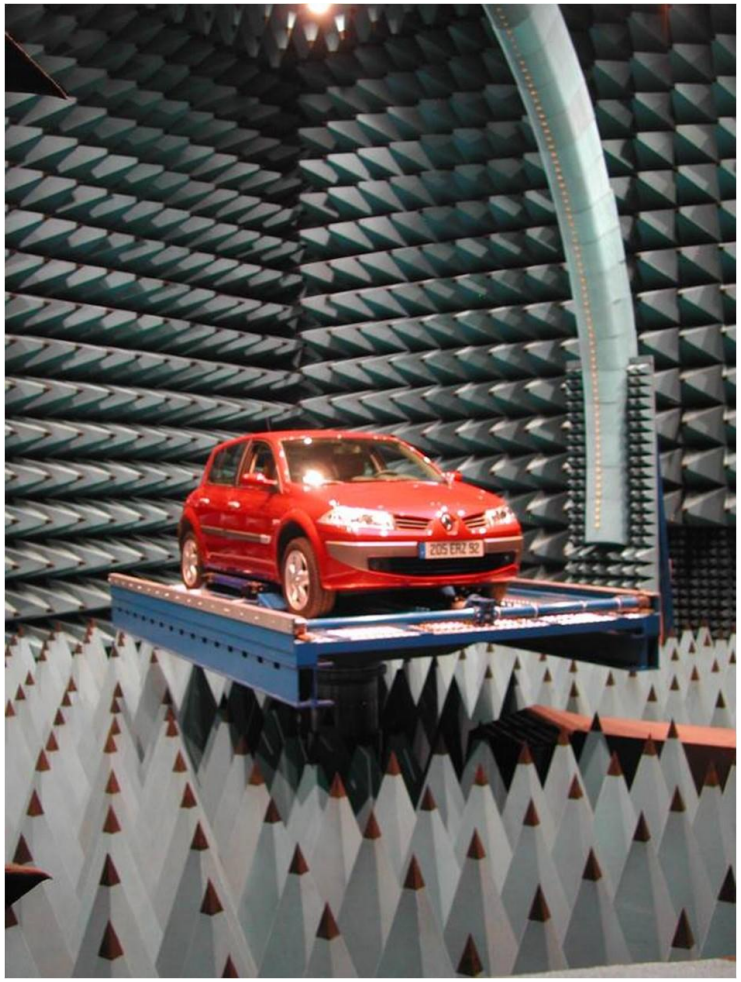
Typical anechoic chamber

CTIA = Cellular Telecommunications & Internet Association
TRP = Total Radiated Power
TIS = Total Isotropic Sensitivity

Vehicle Antenna Range Measurements

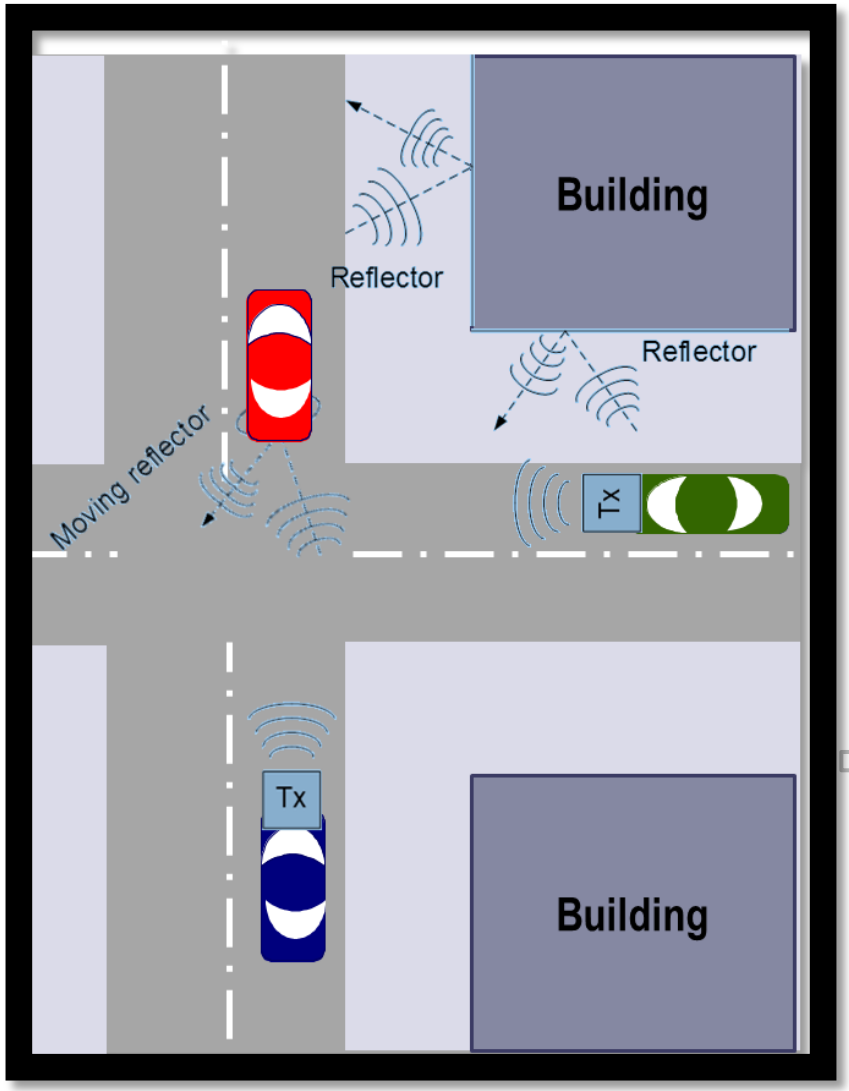
- With modern connected cars, multiple radios and their antennas need to be characterized in 3D



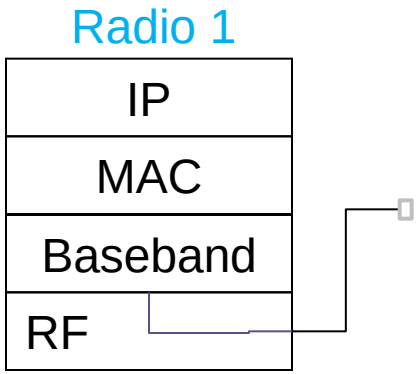


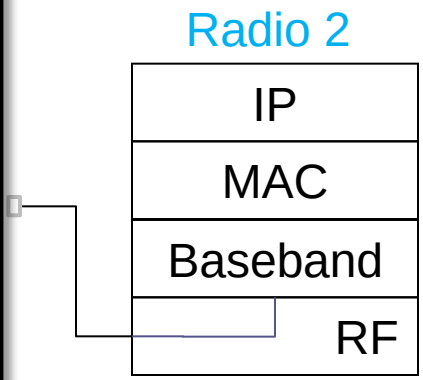
Wireless Channel Emulation

A wireless channel emulator is a 'black box' that connects to antenna ports of two or more radios and inside emulates a wireless channel.



Wireless channel emulation involves emulating multipath reflections and Doppler fading due to moving reflectors or moving radios.





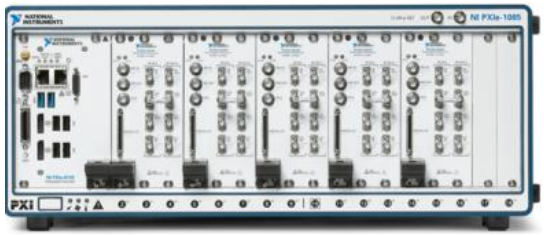
Wireless channel emulator

Example Wireless Channel Emulators

Azimuth ACE

Spirent VR5

Elektrobit Propsim (Just acquired by Anite Telecoms)



octoScope octoFade based on National Instruments VST module (coming soon)

octoScope

Contents

- Standards-based wireless test methods and metrics
- Challenges specific to DSRC radios
- Comparison of DSRC evaluation techniques
- Merits of controlled environment testing

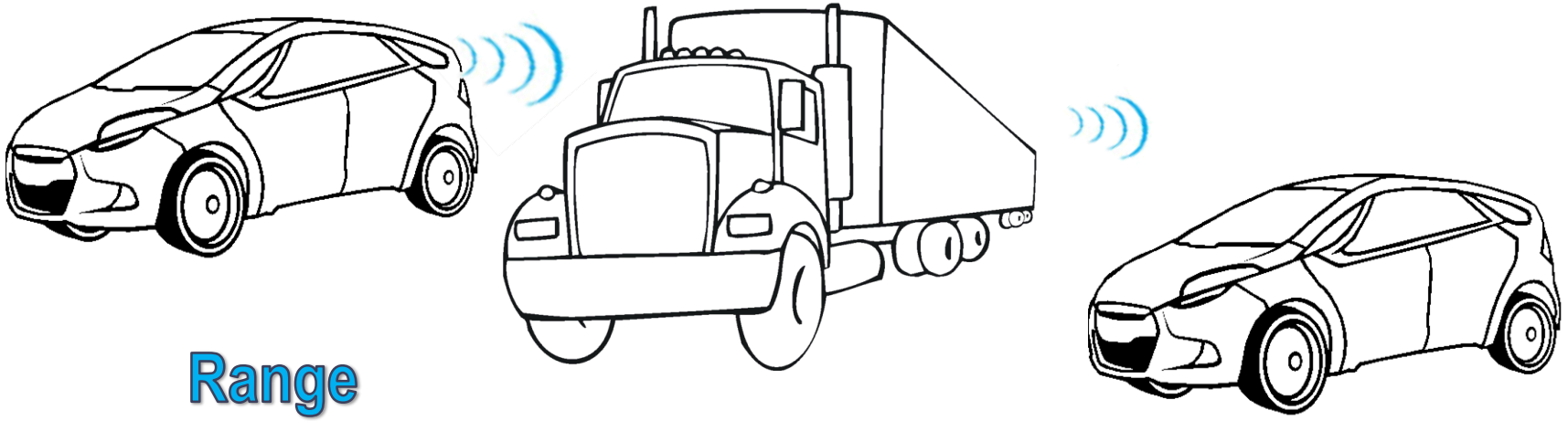
DSRC Radio Challenges

- Fast motion of radios
- Fast motion of reflectors
- Challenging multipath conditions
  - E.g. urban tunnels can result in long delays on strong multipath reflections that 802.11 OFDM is not designed to handle*
- Data traffic congestion scenarios
  - High density of radios and 'hidden node' scenarios could cause inefficiencies in the 802.11 CSMA/CA protocol, which in turn could result in a high PER

* Described by 3GPP Urban Macro and Urban Micro channel models

CSMA/CA = carrier sense multiple access with collision avoidance
PER = packet error rate
OFDM = orthogonal frequency division multiplexing

Many Things To Test at the Radio Layer



Range

Latency

Adjacent channel interference

Conformance

Packet error rate

Backwards compatibility

Interoperability

Authentication speed

Medium access behavior

octoScope

Lots of 'Knobs' Controlling the Test

Data traffic

Multipath

Interference

Noise

Radio density

Shadowing

Security

QoS

Motion of radios

Motion of reflectors

Contents

- Standards-based wireless test methods and metrics
- Challenges specific to DSRC radios
- Comparison of DSRC evaluation techniques
- Merits of controlled environment testing

octoScope

Evaluation Techniques

Assessment	Computer simulation	Field test	Controlled environment test
Performance of mission-critical DSRC apps	☐	■	■
Driver experience with user interface	◪	■	☐
Performance of radio module		◪	■
Control of radio channel conditions (multipath, Doppler, noise, etc.)	☐	☐	■
Realism of radio channel conditions		■	◪
Monitoring performance and behavior of radio module in challenging RF environment or under heavy traffic load		☐	■
Monitoring performance and behavior of mission-critical DSRC apps in challenging RF environment or under heavy traffic load	☐	◪	■
Traffic load and DSRC station emulation	◪		■
FCC authorization not required for test			■
Test automation, including DUT configuration and test environment control (for QA testing)			■

QA = quality assurance

■ Excellent ◪ Average ☐ Poor

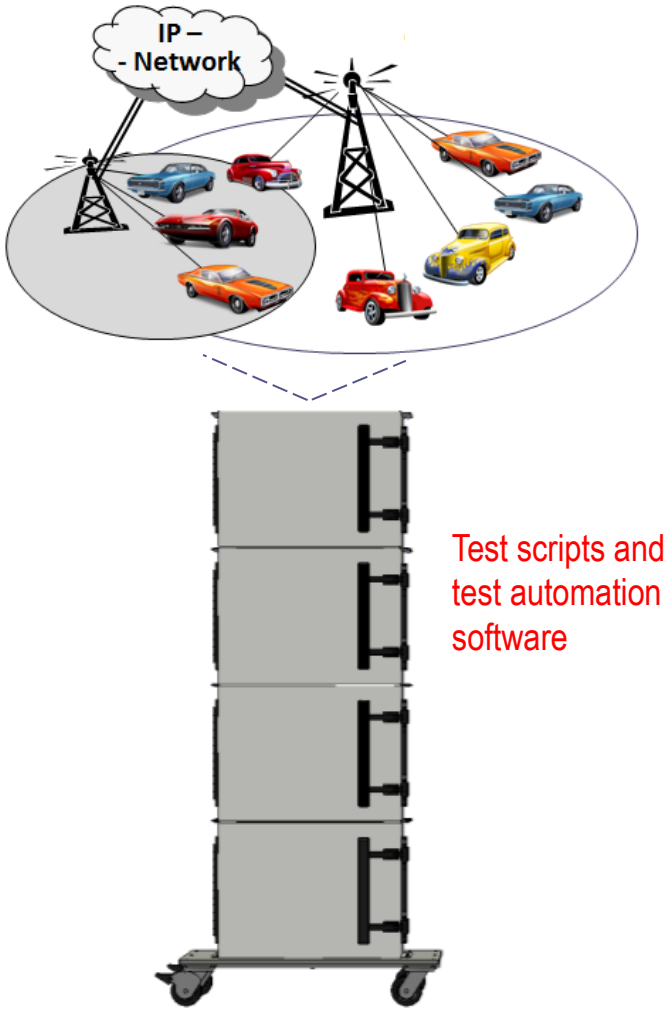
octoScope

Contents

- Standards-based wireless test methods and metrics
- Challenges specific to DSRC radios
- Comparison of DSRC evaluation techniques
- Merits of controlled environment testing

Controlled Environment Testing

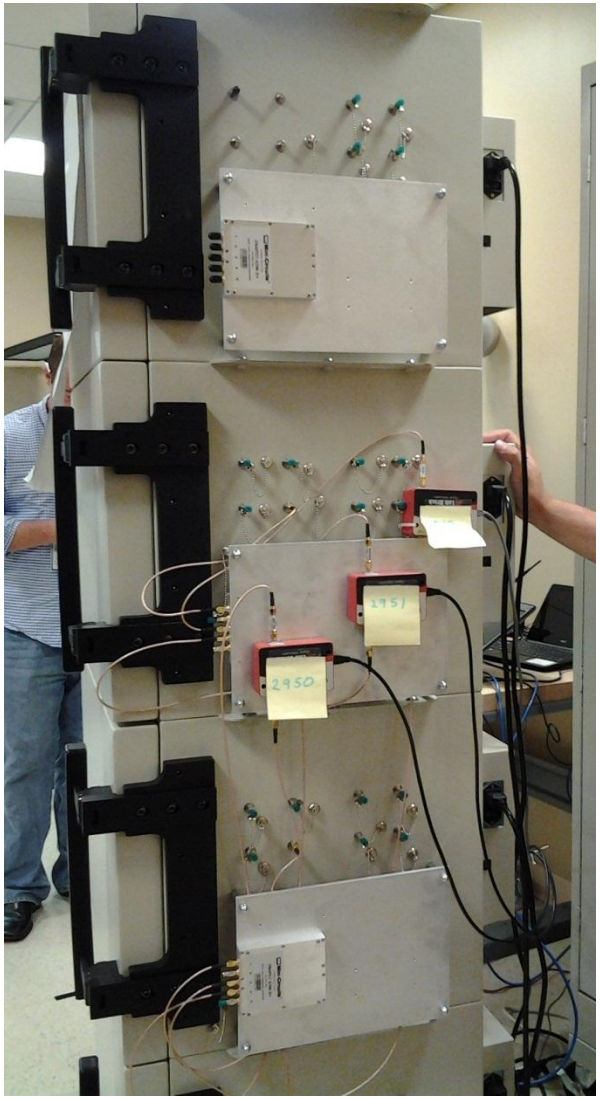
- Repeatable test results
- Control over test conditions
- Ease of test automation
- RF isolated testbed enabling testing of new devices without the FCC authorization
- Testbed can be replicated in multiple locations around the world (e.g. at multiple certification laboratories)



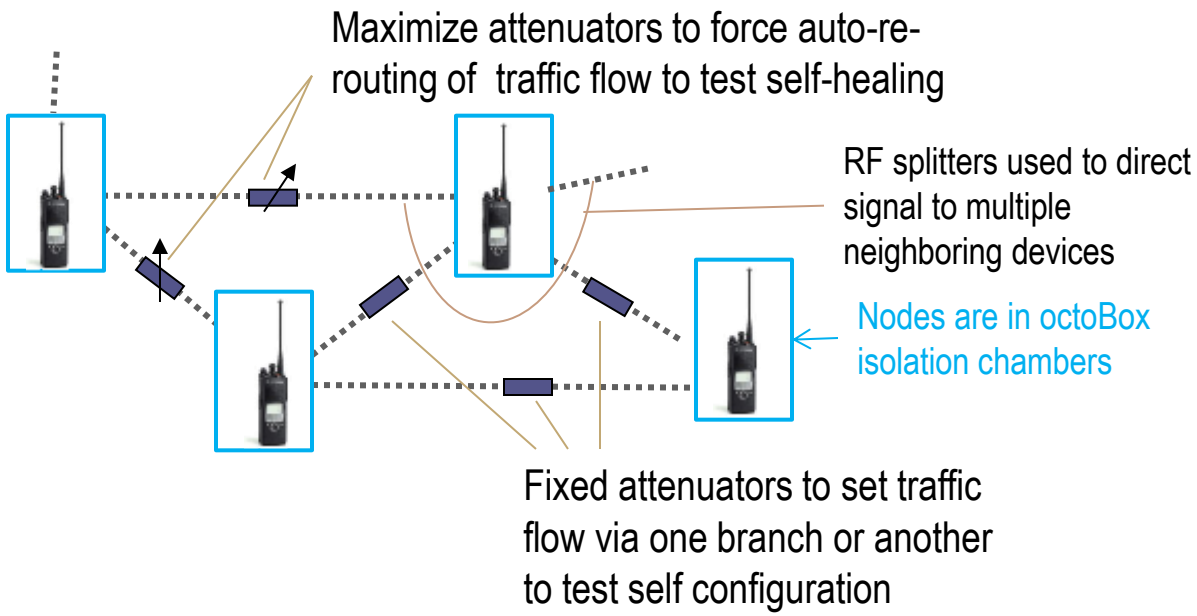
Radio Test in a Controlled RF Environment

- Radio under test is placed into an isolation chamber, preferably anechoic (non-echoing)
- Testbed is built by
  - Interconnecting the devices in isolation chambers via controllable RF signal paths
  - Connecting test equipment, such as RF channel emulators, analyzers and monitors into the testbed
  - Creating test automation software to manage test conditions and to configure devices under test (DUTs)

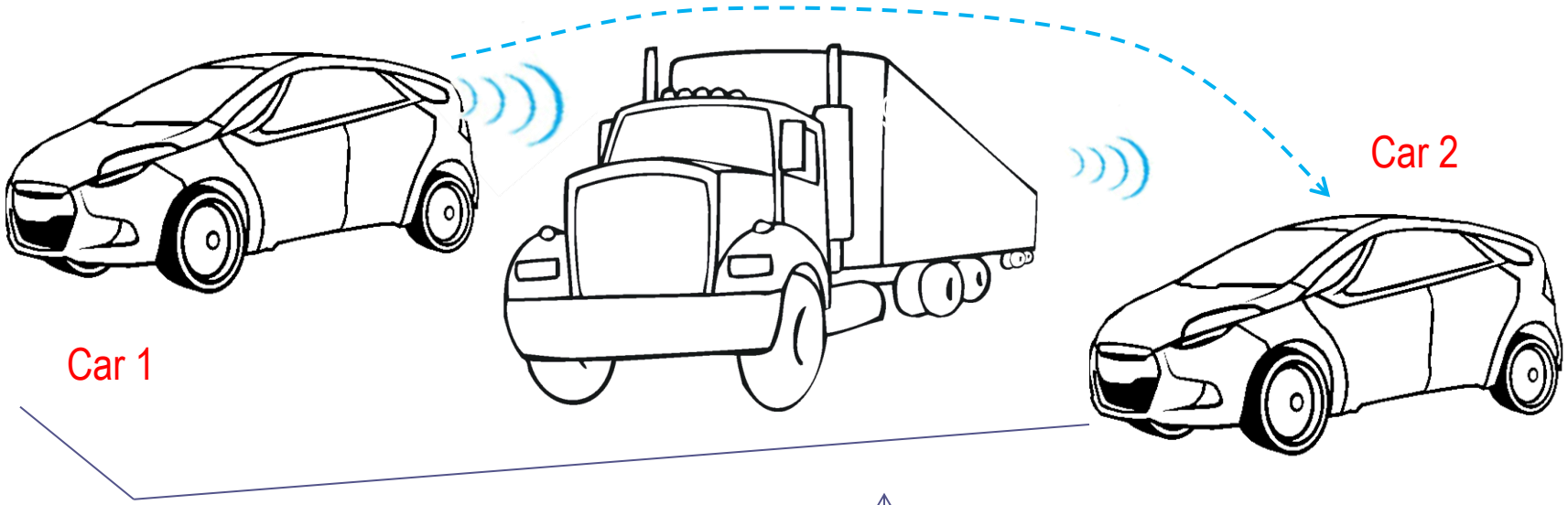
Example - Wireless Mesh Testbed

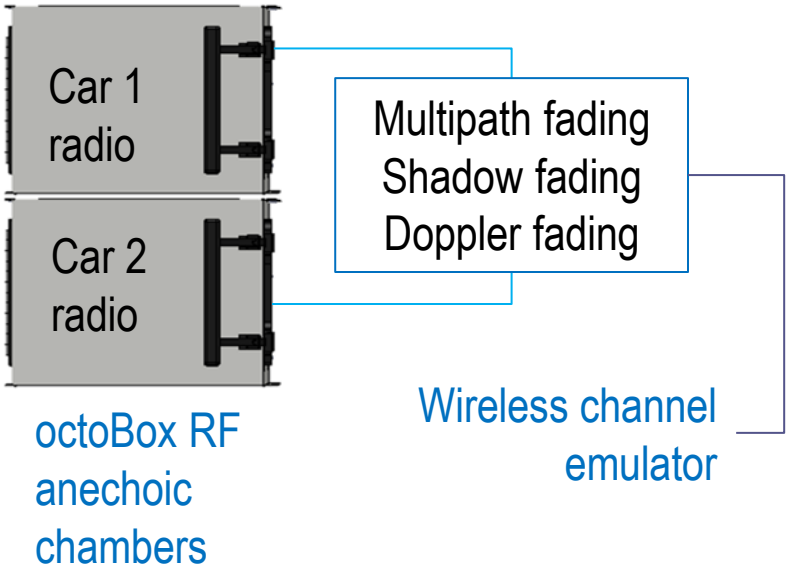


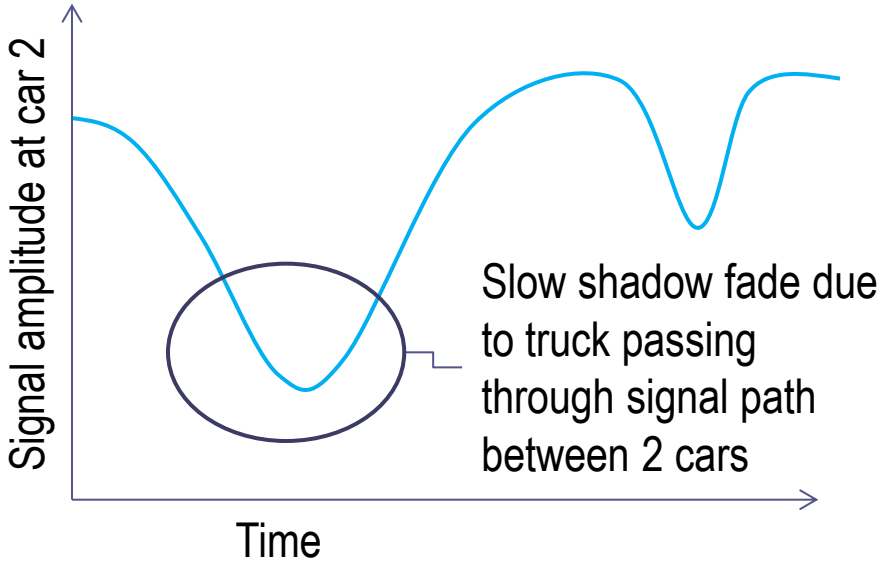
octoBox quadStack isolation enclosures with built-in RF combiners and attenuators



Channel Emulator to Emulate Road

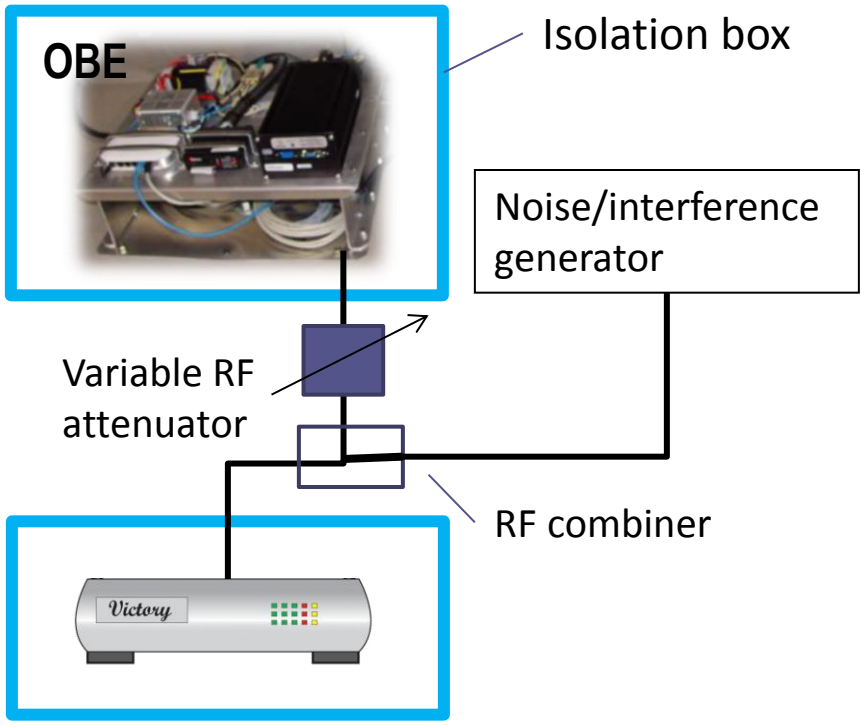




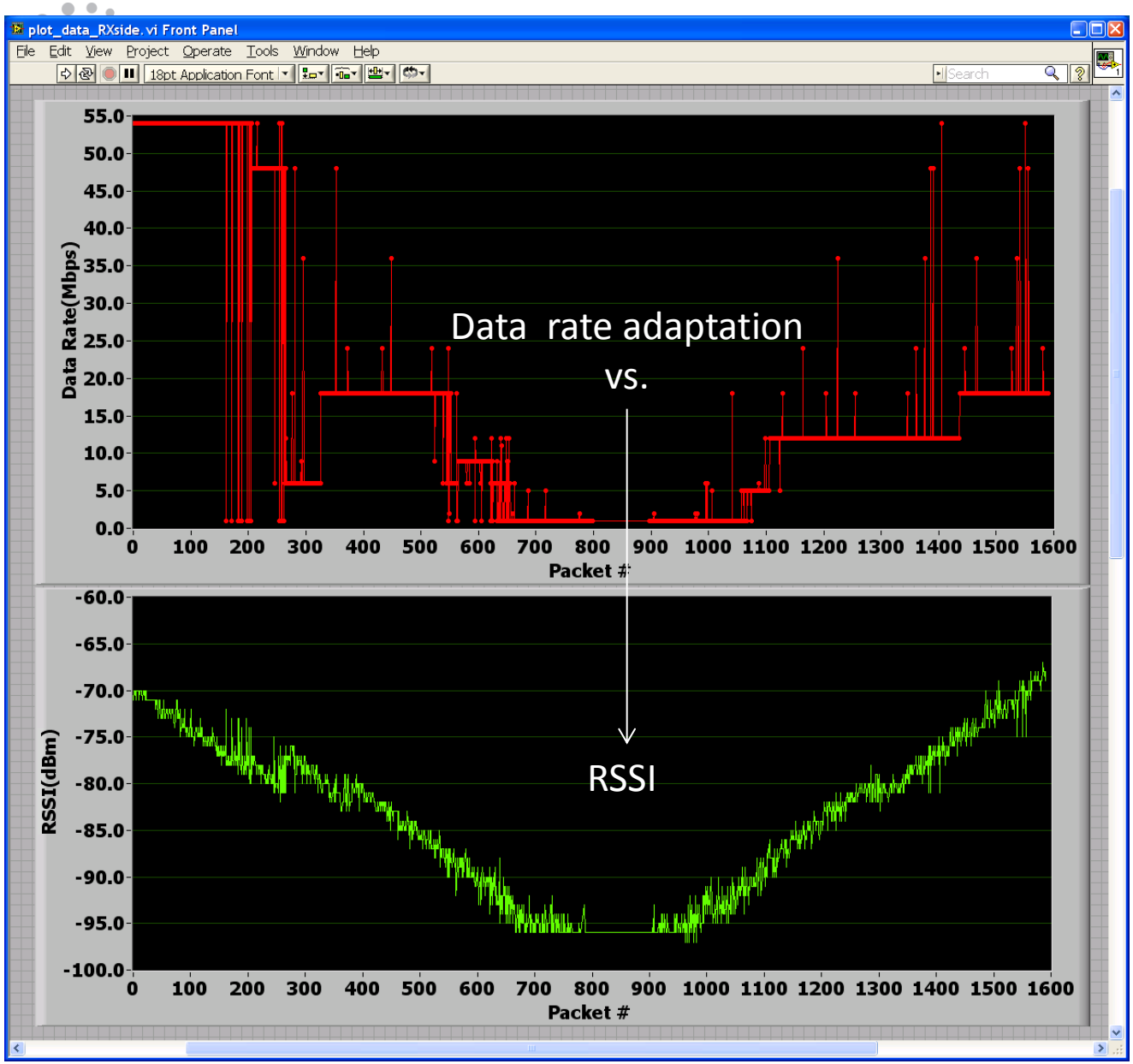


Basic Radio Performance Tests

- RX sensitivity
- TX spectrum, EVM
- Range
- Adaptive modulation
- Roaming behavior
- Performance in the presence of noise and interference



DUT = device under test
EVM = error vector magnitude
OBE = on-board equipment



Controlled Environment Measurement Example

Noise, interference and Master to DUT coupling must be well below intended signal level at DUT for metrics such as rate/MCS adaptation or roaming performance

802.11b (DSSS-CCK)
– 1, 2, 5.5, 11 Mbps; 2.4 GHz
802.11a (OFDM)
– 6, 9, 12, 18, 24, 36, 48, 54 Mbps; 5 GHz
802.11g
– both 11b and 11a rates; 2.4 GHz
802.11n
– up to 600 Mbps; 2.4 and 5 GHz

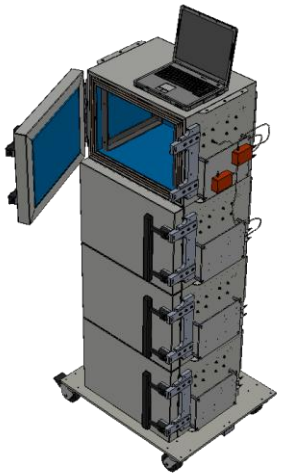
MCS = modulation coding scheme
DUT = device under test

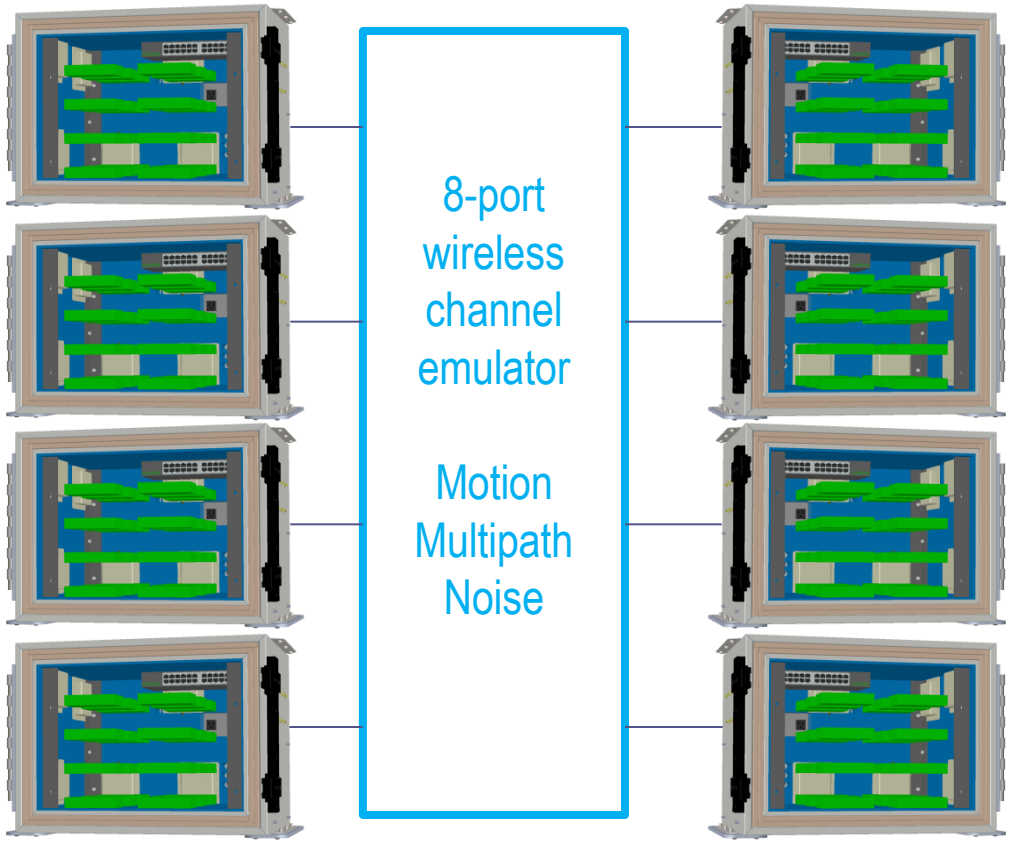
Example Large-scale DSRC Testbed

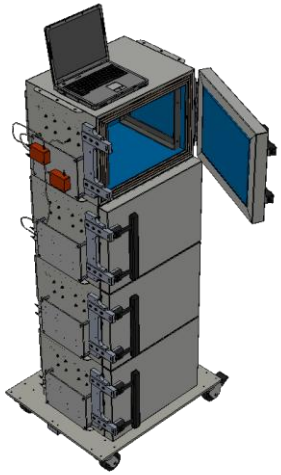
DSRC testbed emulates motion of groups of cars with respect to other groups

Up to 24 radio modules in each chamber

192 radios in the testbed







octoBox quadStack

Concluding Thoughts

- The DSRC industry has done a lot of good work on real-life outdoor testing.
- The next step for the industry is to consider creating a test standard to ensure
  - Robust performance of mission-critical DSRC applications
  - Interoperability
  - Backwards compatibility (as time goes on)
- Controlled RF environment is extensively used in the wireless industry for R&D, QA and certification testing and may be beneficial to consider for DSRC.

Thank you!

- Please visit www.octoscope.com to view our white papers, presentation and webinars on the topic of wireless technologies and wireless test
- Contact
  - Fanny Mlinarsky
    Mobile: 978.376.5841
    Email: fm@octoscope.com

225 Cedar Hill Street
Suite 200
Marlborough, MA 01752 USA

Tel: +1.978.222.3114
Fax: 1.866.401.5382
www.octoScope.com

525 East Seaside Way
Suite 705
Long Beach, CA 90802 USA