

智能网联汽车测试挑战和测试方案

金海良
罗德与施瓦茨公司 高级总监

ROHDE & SCHWARZ

Make ideas real



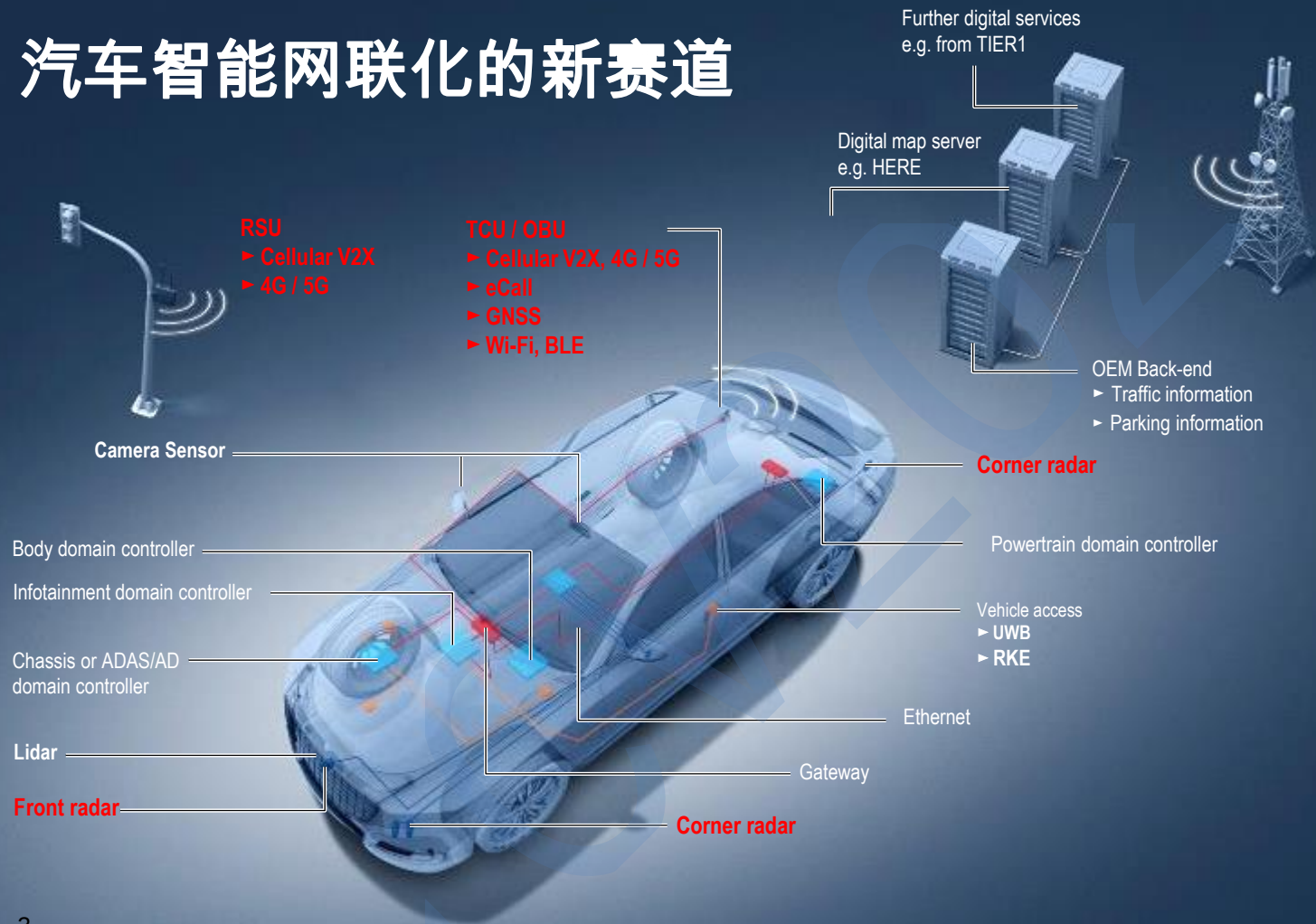
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罗德与施瓦茨公司基本情况

History	Type of Enterprise	Global Presence	Net Revenue	Employees	Success
Established 1933 in Munich, Germany	Independent family-owned company	In > 70 countries, more than 60 subsidiaries	EUR 2.58 billion (FY 19/20)	12,300 worldwide	A leading supplier in all business fields



汽车智能网联化的新赛道



传感器 汽车的眼睛和耳朵

毫米波雷达

C-V2X, 4G, 5G

Lidar, Camera

中国车联网研发和应用领先世界

China C-V2X key milestone

China First
C-V2X Plugfest

C-V2X starting to
equipped in new
vehicles

50% new vehicle
equipped C-V2X
-CSAE estimation

2018 2019 2020 2021 2022 2023 2024 2025

V2X Spectrum
Launched

China-NCAP
Planning to add C-V2X

Roadmap: active-safety

	2022	2023	2024
Intent		New audit items were added: New, collision warning based on C-V2X	Evaluation: Add more scenarios with higher requirement, such as side collision and CCPAP, based on the state of art new technologies such as AEB, V2X, IMA...
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	2022	2023	2024
Drive		New audit items were added: New, Collision warning with low speed or reverse	From Audit to Evaluation: If necessary based on the state of art
assist		New audit items were added: New, Traffic light, Reverse based on the state of art, such as V2X	From Audit to Evaluation: necessary based on the state of art
Category D		New audit items were added: New, SLF and warning function when exceed the speed limit	
Traffic sign aid			

C-NCAP Adding C-V2X For Active Safety Function In 2023
R&S Being Asked C-V2X Test Solution for C-NCAP Now



More than 40 OEMs Joined 2020 "Cross-Industry"
C-V2X Plugfest In Shanghai

中国构建了自己的C-V2X标准体系

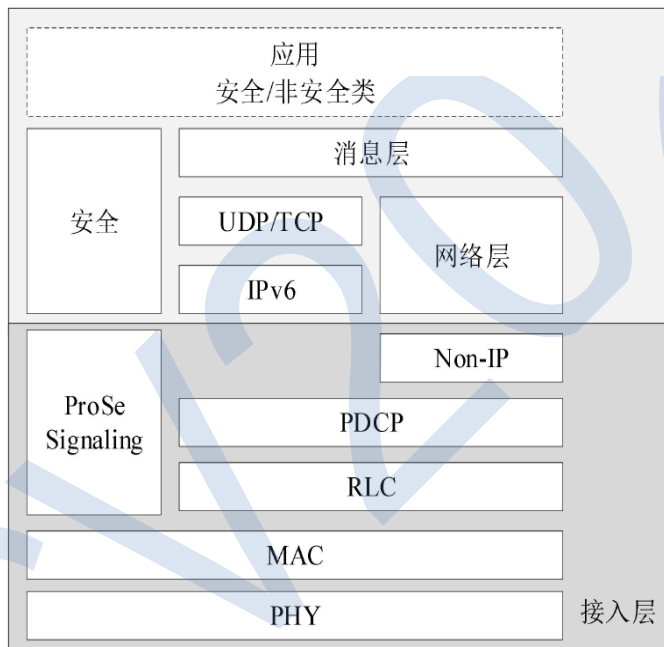
Automotive requirement (标准组织 : NTCAS) GB/T

► 基于LTE-V2X 直连通信的车载信息交互系统技术要求

1. 车载射频测试
2. 通信安全测试
3. 可靠性测试, 电气性能测试, EMC测试
4. 天线测试
5. 定时定位测试
6. 数据一致性测试

Automotive Use Case (标准组织 : NTCAS)

► 基于网联技术的汽车安全预警类应用场景标准化研究报告



Application (By : C-SAE) – ref to SAE 团标

- 合作式智能运输系统车用通信系统应用层及应用数据交互标准
- 合作式智能运输系统车用通信系统应用层及应用数据交互标准第二阶段

Message Layer (By : CCSA)

- 基于LTE 的车联网无线通信技术消息层技术要求
- 基于LTE 的车联网无线通信技术消息层测试方法

Network layer (By : CCSA)

- 基于LTE 的车联网无线通信技术网络层技术要求
- 基于LTE 的车联网无线通信技术网络层测试方法

Security (By : CCSA)

- 基于LTE 的车联网通信安全技术要求
- 基于LTE 的车联网无线通信技术安全认证技术要求
- 基于LTE 的车联网无线通信技术安全认证测试方法

Access (By : CCSA)

- 基于LTE 网络的车联网无线通信系统总体技术要求
- 基于LTE 的车联网无线通信技术空中接口技术要求
- 基于LTE 的车联网无线通信技术 支持直连通信的车载终端设备技术要求

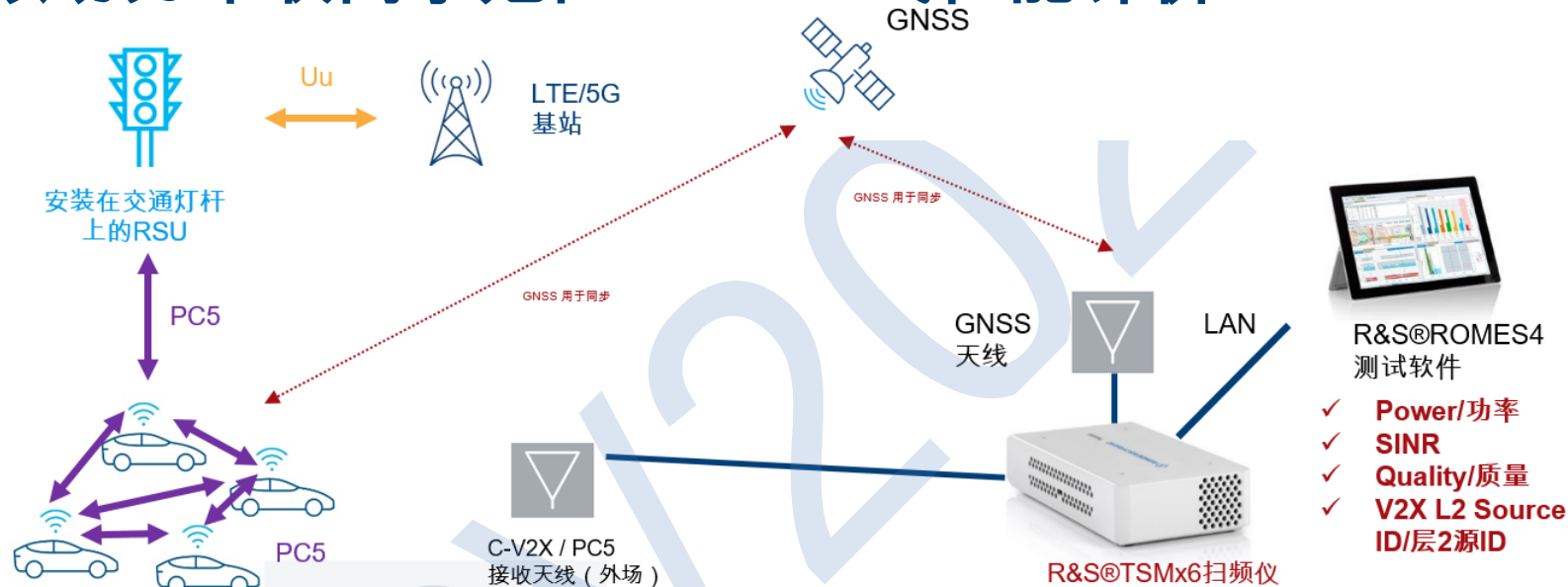
车联网落地的实际挑战



车联网 C-V2X , 4 / 5 G

1. 车联网示范区需要完善的无线性能评估方法—C-V2X无线信号覆盖评价
2. C-V2X车联网外场无线环境无法重复，交通场景数量少，测试时间长和效率低等问题
3. 解决汽车T-Box 4/5G外场上网问题，定位问题需要的时间长，涉及人员多
4. OTA (远程下载) 网络安全问题

扫频助力车联网示范区C-V2X无线性能评价



每个V2X信号发送源列为一行

V2X Scanner Top N View :1 R&S LTE Scanner[1]

Top N: Show all TopN Pools								
List								
(#	T..	V2X L2 Source ID (8 LSB)	Center Frequency [Hz]	EARFCN ...	V2X L2 Source ID	RS-RSSI [dBm]	RSRP [dBm]	RS-CINR [dB]
1	1	255		55140	16777215	-49.88	-71.92	36.23
2	2	0		55140	0	-49.91	-71.94	36.76
3	3	67		55140	40003	-49.88	-71.92	36.11
4	4	68		55140	40004	-49.88	-71.93	35.09

C-V2X 硬件在环复杂交通场景测试



中国汽车工程学会标准

T/CSAE 53-2017

合作式智能运输系统 车用通信系统
应用层及应用数据交互标准

Cooperative intelligent transportation system; vehicular communication;
application layer specification and data exchange standard

T/CSAE 53-2017

5.2.3 交叉路口碰撞预警

5.2.3.1 应用定义和预期效果

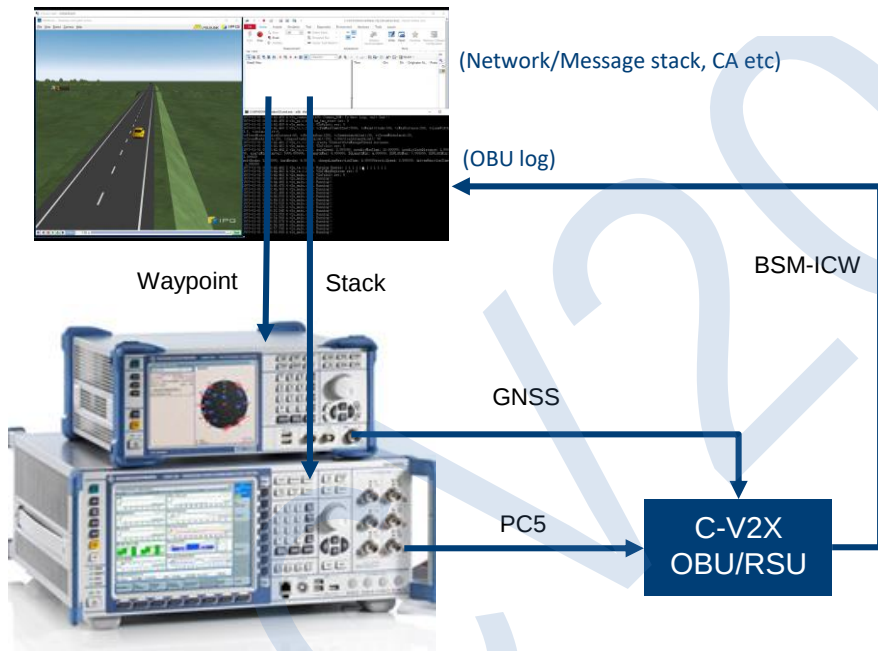
交叉路口碰撞预警 (ICW: Intersection Collision Warning) 是指, 主车 (HV) 驶向交叉路口, 与侧向行驶的远车 (RV) 存在碰撞危险时, ICW 应用将对 HV 驾驶员进行预警。本应用适用于城市及郊区普通道路及公路的交叉路口、环道入口、高速路入口等交叉路口碰撞危险的预警。

ICW 应用辅助驾驶员避免或减轻侧向碰撞, 提高交叉路口通行安全。

Traffic scenarios
simulation

GPS
Simulation
(SMBV100B)

Vehicle Simulation
(CMW500)



外场4/5G网络转实验室测试加快问题解决

外场信息采集

数据分析，导出，脚本重建

实验室回放，测试迭代



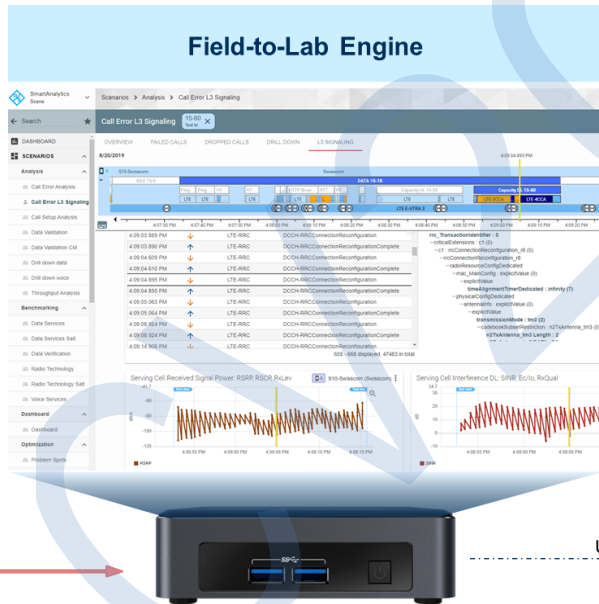
Qualcomm

QualiPoc

ROMES

NEMO/TEMS

CMX msglog



User on NUC PC

Rohde & Schwarz

Cell Info	Broadcast	OTA Signaling	RSRP
PLMN, Band, MIMO, ...	MIBs & SIBs	RRC, NAS, IMS	✓

Test Scripts /
Network Config



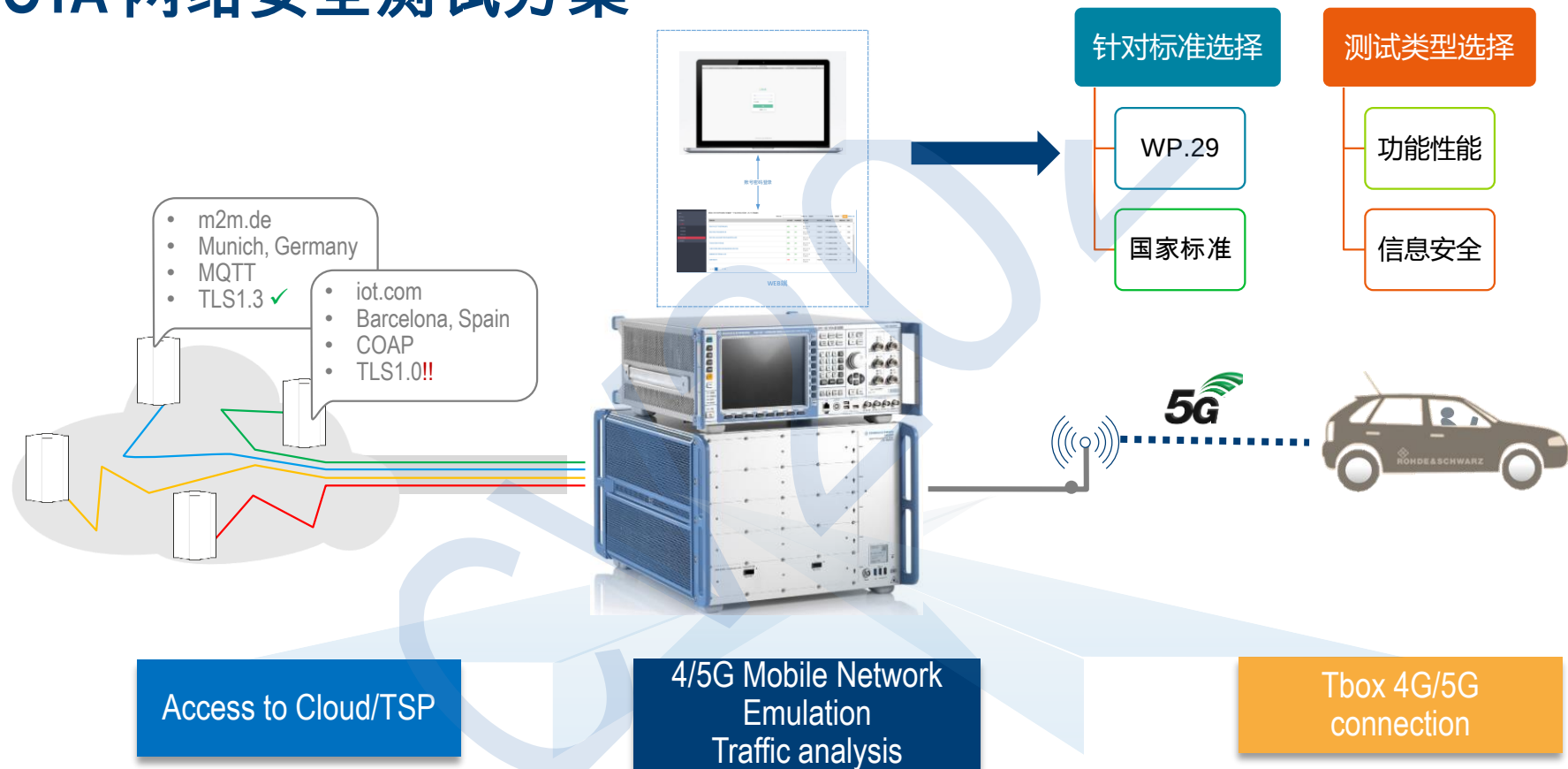
CMX F2L Device verification Test cases

User on CMX



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OTA 网络安全测试方案



智能驾驶落地的实际挑战

Validation costs of "Automated Driven Vehicles" will higher as the development itself. **Bernd Bohr, former CEO Bosch**

Infinite high number of test cases

The biggest challenge is not cause failures. One has to execute 250 million test kilometers states the **Bosch Executive Director**.

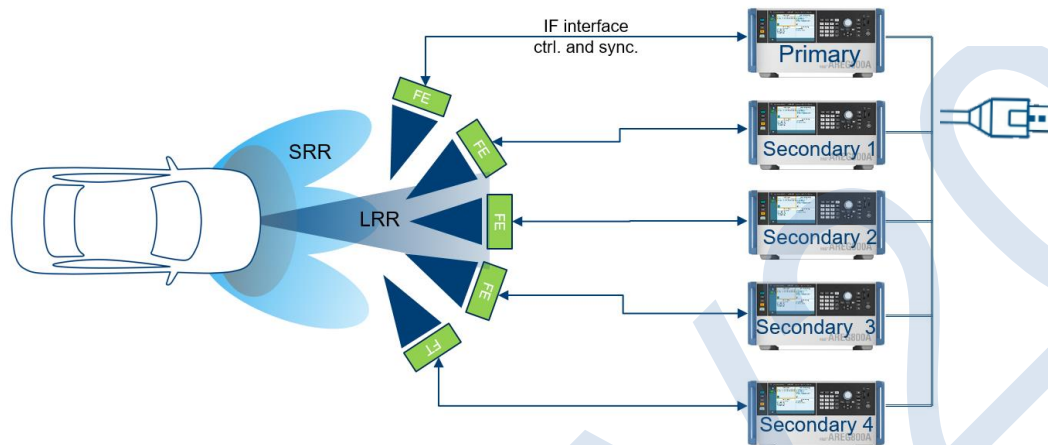
Calculation Example:
Requirement=250Mkm within 2 months:
4 200 000 km/day or
3 500 vehicles in parallel (7/24, 50kph avg)



汽车毫米波雷达和电磁兼容

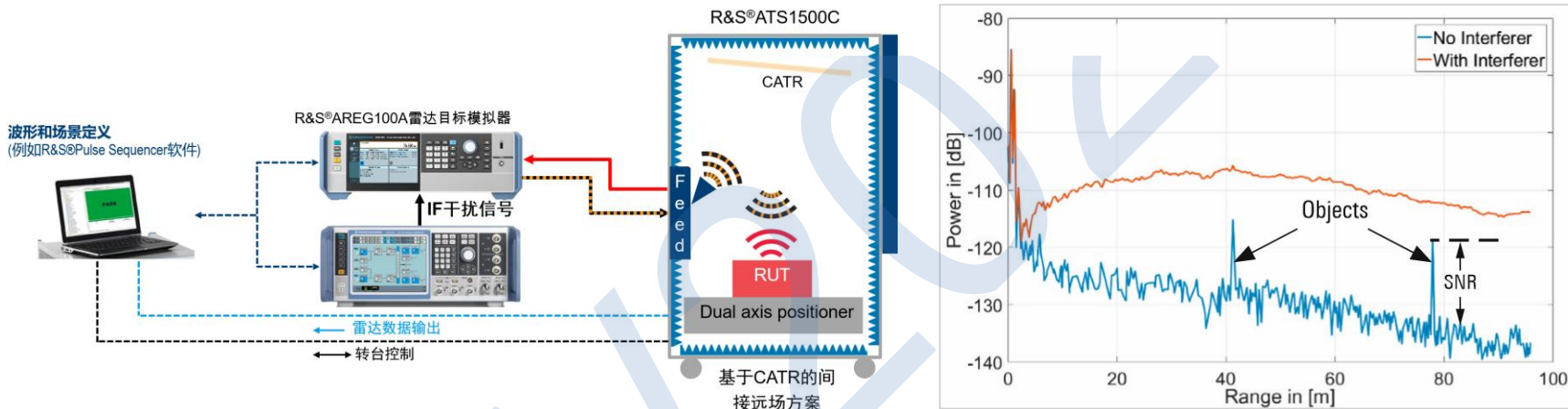
1. 4D雷达测试是新课题，雷达硬件在环测试搭建多目标和复杂场景困难大
2. 射频干扰导致的雷达性能下降问题评估
3. 雷达，摄像头，导航和C-V2X等多传感器融合下智能网联汽车的性能测试和认证方案缺乏
4. 如何克服和测试道路上复杂电磁干扰

多目标复杂交通场景的4D雷达在环测试和仿真



- ▶ 能够满足多目标复杂场景的雷达模拟器是构建雷达在环测试的重要设备
 - Instantaneous measurement of Range, Doppler, Azimuth and Elevation(4D)
 - Lidar like 3D image resolution
 - 4th dimension of time: Instantaneous hi-resolution velocity information for every reflection
- ▶ **Virtual aperture** by evaluation of transmitted radar signal

雷达干扰场景模拟和测试



- Connect any analog or vector signal generator up to 6 GHz to the AREG I/F input port
- Impose interferes onto the wanted echoes and share the AREG frontend for up conversion for both signals
- Cost optimized and simple solution for simulation of wanted echoes together with interferers
- Use SMW200A vector signal generator and R&S Pulse Sequencer Software for advanced interfering scenario e.g. from multiple fast chirp sequences

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AVL



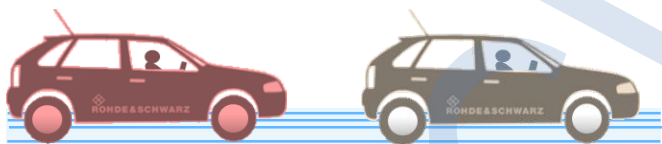
基于传感器融合的整车在环测试方案“DRIVINGCUBE”- RADAR/CAMERA/GNSS/C-V2X/ULTRATRONICS

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复杂电磁环境下汽车辅助驾驶功能的测试

测试流程

- Activate AEB-CCRb function	Passed
- Reduced car speed from 50 to 38 km/hr	Passed
- Turn ON Brake light	Passed
- Display warning on dashboard	Passed

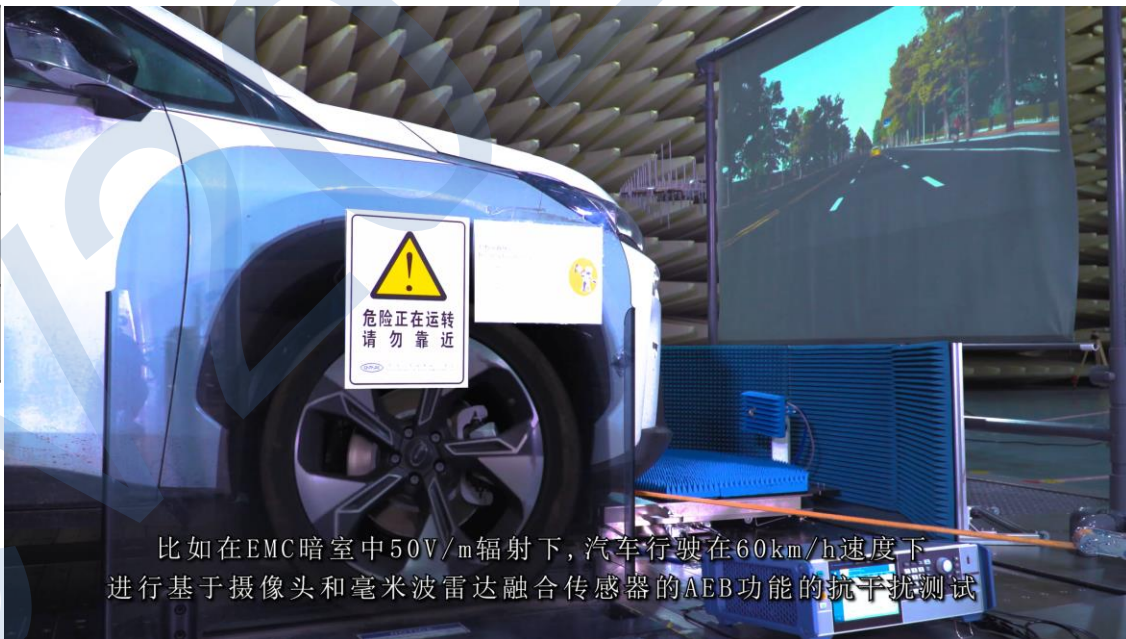


Test vehicle

- 50km/h
- Normal driving

AREG setting

- 15m & 4m
- 10 to -3km/hr
- 10 dBsm



比如在EMC暗室中50V/m辐射下, 汽车行驶在60km/h速度下进行基于摄像头和毫米波雷达融合传感器的AEB功能的抗干扰测试

领先的汽车解决方案



Automotive Connectivity Test
R&S®CMX500/CMW500/SMBV100B



Automotive EMC and Full Vehicle Antenna Test
R&S®EMC/OTA Test System



Automotive Domain Controller and Ethernet
R&S®RTO/RTP/ZNB



Automotive Infotainment
R&S®BTC/VTE



Electric Vehicle Test
R&S NGM/NGP power supply



Automotive ECU ICT/FCT Test
R&S®TSVP



Automotive Radar Test
R&S®FSW/AREG/ATS1500

谢谢！

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