

# LTE Testing Efforts

Public Safety Broadband Demonstration  
Network Stakeholder Meeting  
March 2012

**Tony Opferman**

**Business Development Manager  
Wireless Communications**

**75** Years of  
Driving  
Innovation

 **ROHDE & SCHWARZ**

# Rohde & Schwarz at a Glance

- Independent, autonomous company
- For more than 75 years, the specialist in T&M and wireless communications
- Represented in over 70 countries, with subsidiaries in 60 countries
- Turnover of EUR 1.9 billion (FY 10/11)
- Export share approx. 90 %
- 7600 employees worldwide



# Rohde & Schwarz

## Fields of business

### I **Wireless communications**

Development and production test solutions for every second mobile phone in the world

### I **Analog & digital TV**

Transmitters for more than 80 countries

### I **Air traffic control**

Radiocommunications for more than 200 large airports

### I **Secure communications**

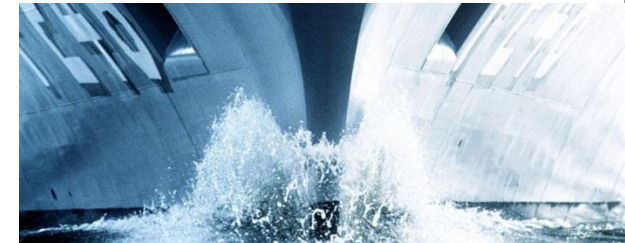
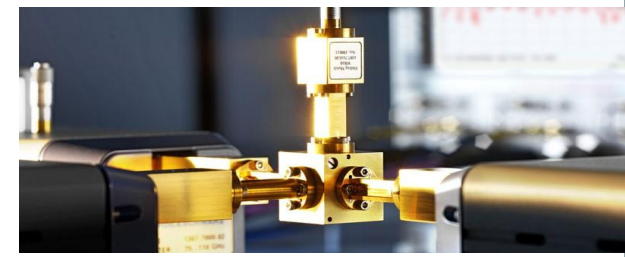
Radios in use worldwide for all branches of the armed forces

### I **Management of the frequency spectrum**

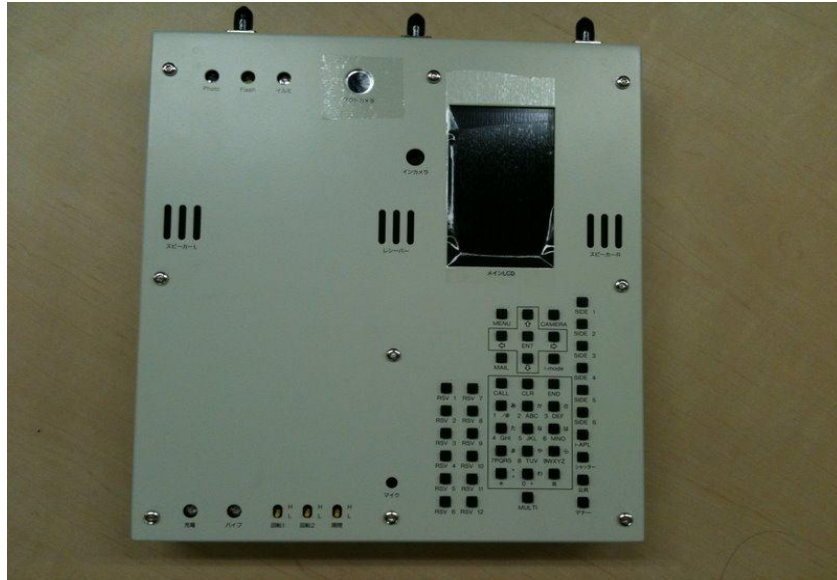
Instruments and systems for radiomonitoring and radiolocation for about 150 countries

### I **Service & services**

To be as close to the customer as possible, nearly 70 locations worldwide



# LTE 2008



# LTE Today

## Juniper Research:

Global LTE service revenues will exceed **\$200bn** by 2015



## IDATE:

Forecasts **371 million LTE subscribers** by 2015

## Pyramid Research:

India set to have over 17 million mobile broadband customers using LTE TDD networks by the end of 2016

**237 operators in 85 countries are investing in LTE**

*GSA, August 31, 2011*

- \* 174 LTE network commitments in 64 countries
- \* 63 pre-commitment trials in 21 more countries
- \* 26 commercial LTE networks launched
- \* At least 93 LTE networks are expected to be in commercial service by end 2012

# Major challenges today with LTE commercialization

## I 3GPP Standards

- I Which baseline to use Sept10, Dec10? Which CRs?
- I Correct interpretation – a lot of IOT testing required!
- I Quarterly baseline updates

## I Interworking with Legacy Technologies

- I InterRAT handovers (GSM, CDMA, WCDMA)

## I Circuit Switch Fallback (CSFB)

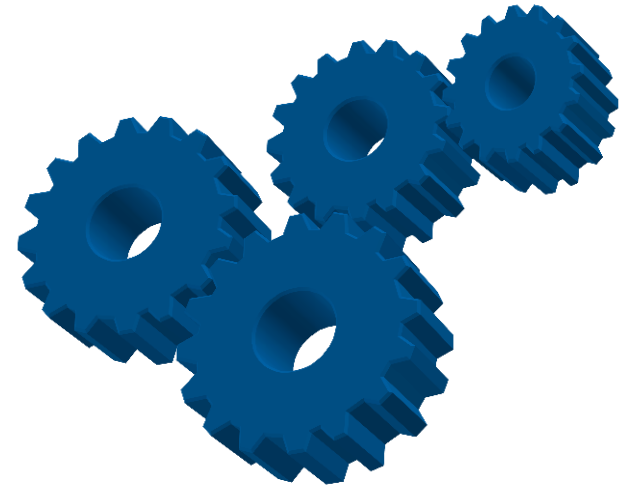
- I Is CSFB only a temporary solution for handling Voice, SMS services?

## I IP Multimedia Subsystem Support

- I Will NWO deploy IMS for LTE and how is this going to be tested?

## I Interferers around the 700 MHz frequency band

- I Eg ATSC



# Major challenges today with LTE commercialization

## I Timely UE Availability

- I Maturity of devices vary – firmware on devices continually updated
- I PTCRB Certification



## I UICC Testing (USIM, CSIM, ISIM)

- I New for some operators

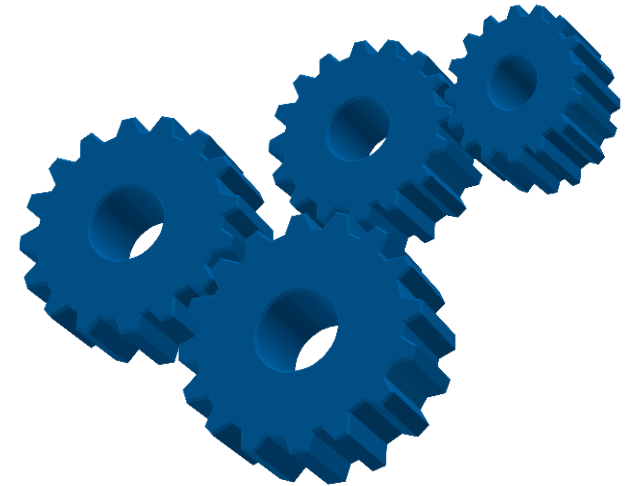
## I MIMO Testing

- I 2x2, 4x2, 4x4 ...

## I Support for both IPv6 and IPv4 data connections

## I Multiple LTE Band Classes to test

## I Interoperability between LTE TDD and LTE FDD technologies



# Major challenges today with LTE commercialization

## I PTCRB Certification

- I Large number of RF and protocol test cases defined
- I TTCN-3 test case delivery; test house readiness

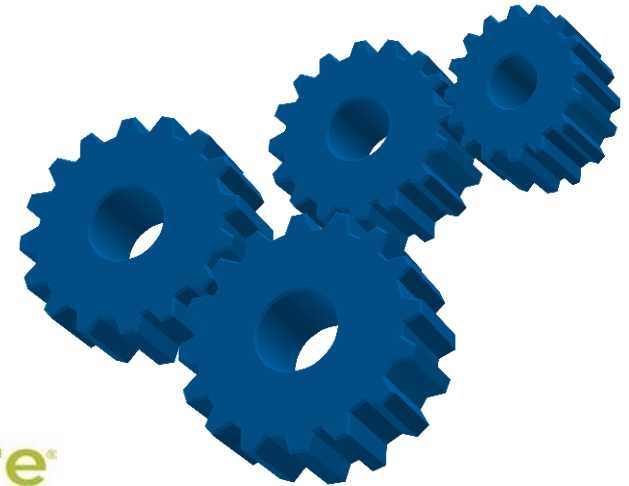


## I Achieving (and sustaining) High Data Rates

## I LTE network operator test plans

- I Developing/Verifying specific operator requirements
- I Test plans continually being released/updated

## I Which Rel 9, 10 features to support

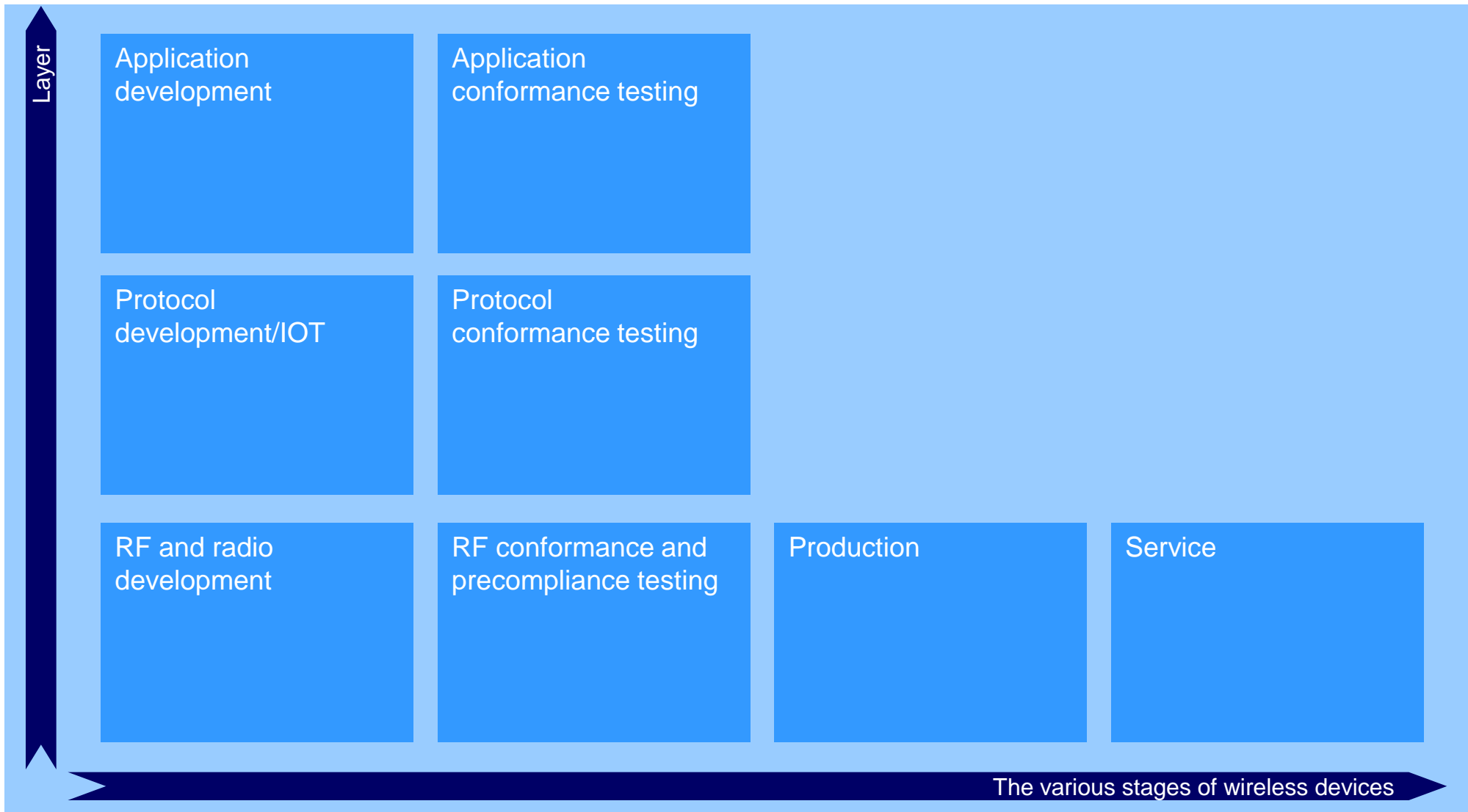




# LTE Testing Methodologies



# LTE Testing Methodologies



# LTE Testing Methodologies

- I Physical Layer**
- I General Protocol**
- I 3GPP Conformance (PCT, RCT)**
- I Performance (Data Throughput, Rx Sensitivity)**
- I OTA**
- I Network Operator Specific**
- I Multimode testing**

# LTE Testing Methodologies

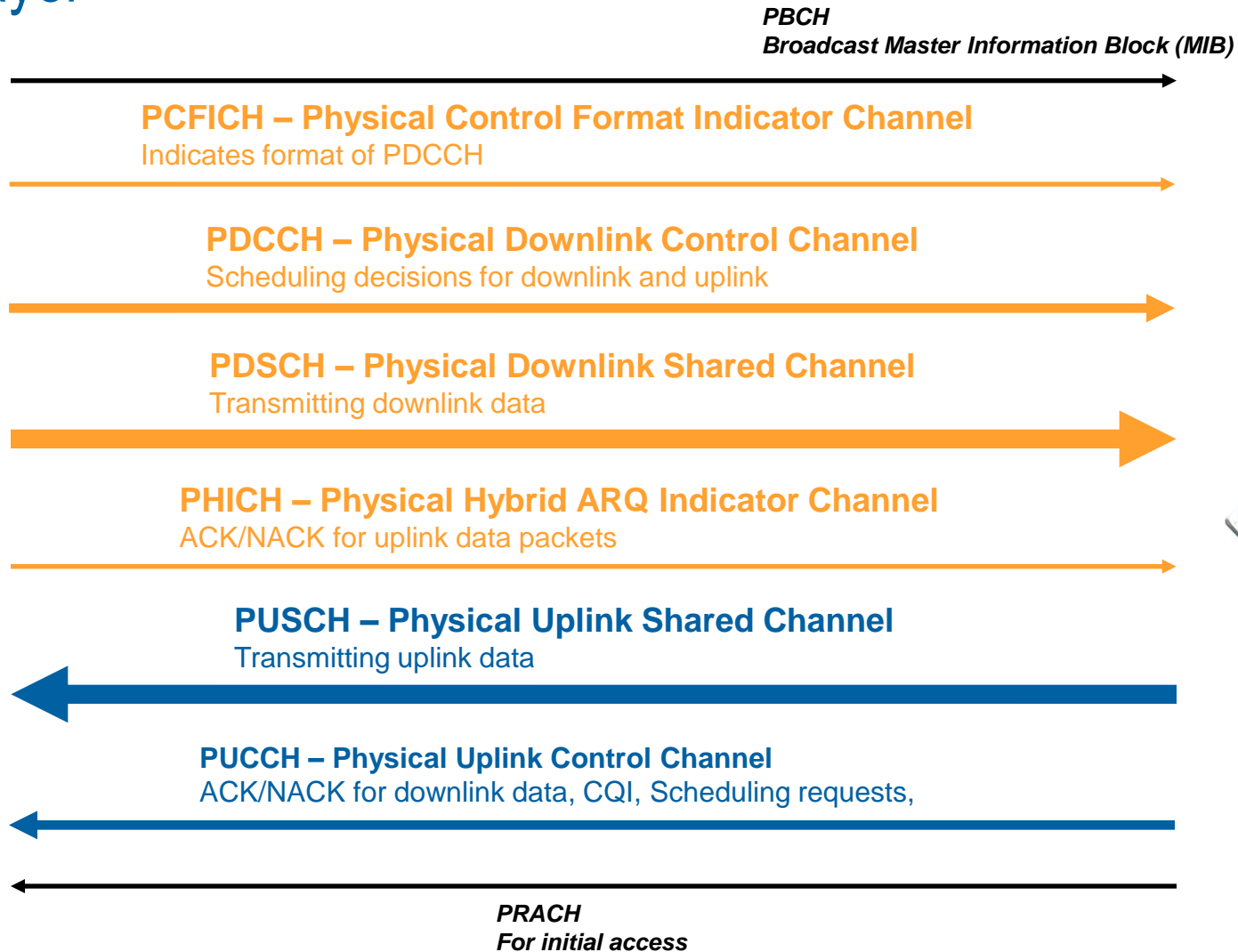
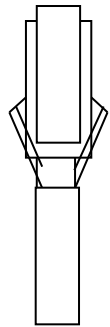
## Physical Layer

### I Validation of LTE Physical Channels w/o Layer 3 signaling

- I Cell Search Verification
- I Negative Testing with DL Error Injection
- I HARQ Procedures
- I Receiver Sensitivity
- I Power Control
- I DL FEC Verification
- I UL FEC Verification

# LTE Testing Methodologies

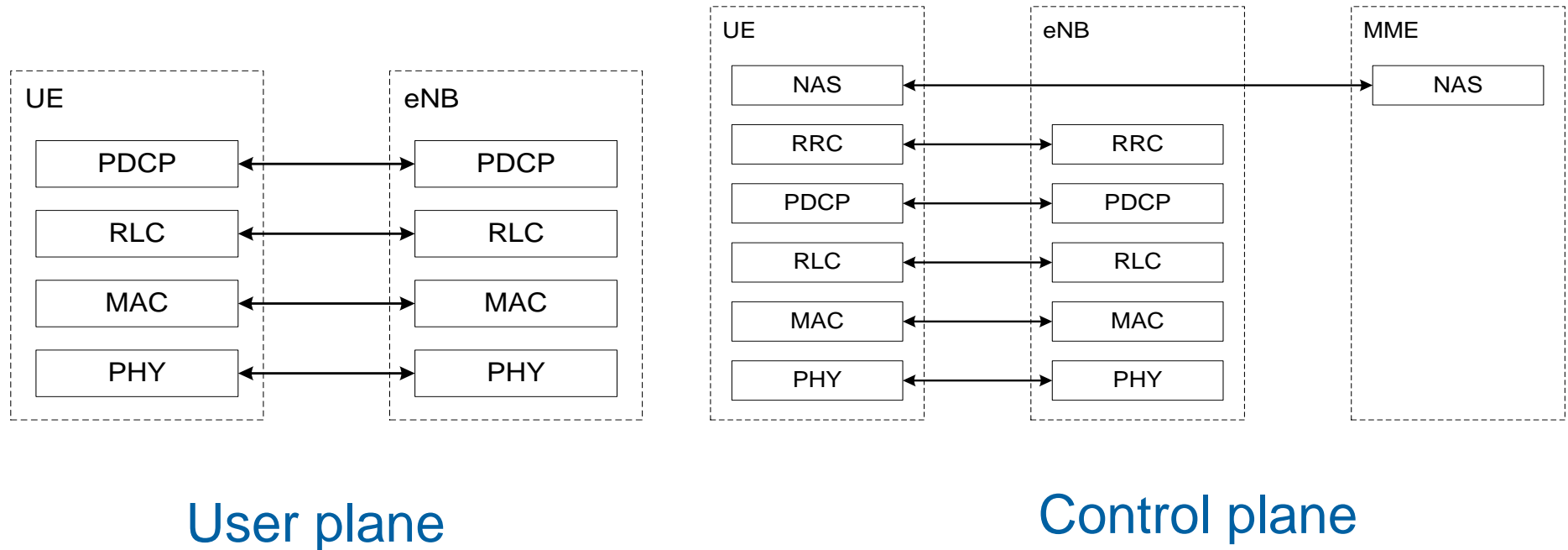
## Physical Layer



# LTE Testing Methodologies

## General Protocol

### I Validation of LTE full stack signaling procedures



# LTE Testing Methodologies

## General Protocol

### I Basic Signaling Procedures

- I Cell Search
- I Setup of RRC connection and execution of Attach Procedure
- I Security Procedures
- I Authentication
- I IPv4 / IPv6, Multiple PDN
- I ...

### I Radio Bearer Verification Procedures

- I Radio Link Control modes - AM/UM/TM
- I SISO vs MIMO

### I IntraLTE and InterRAT Handover Procedures

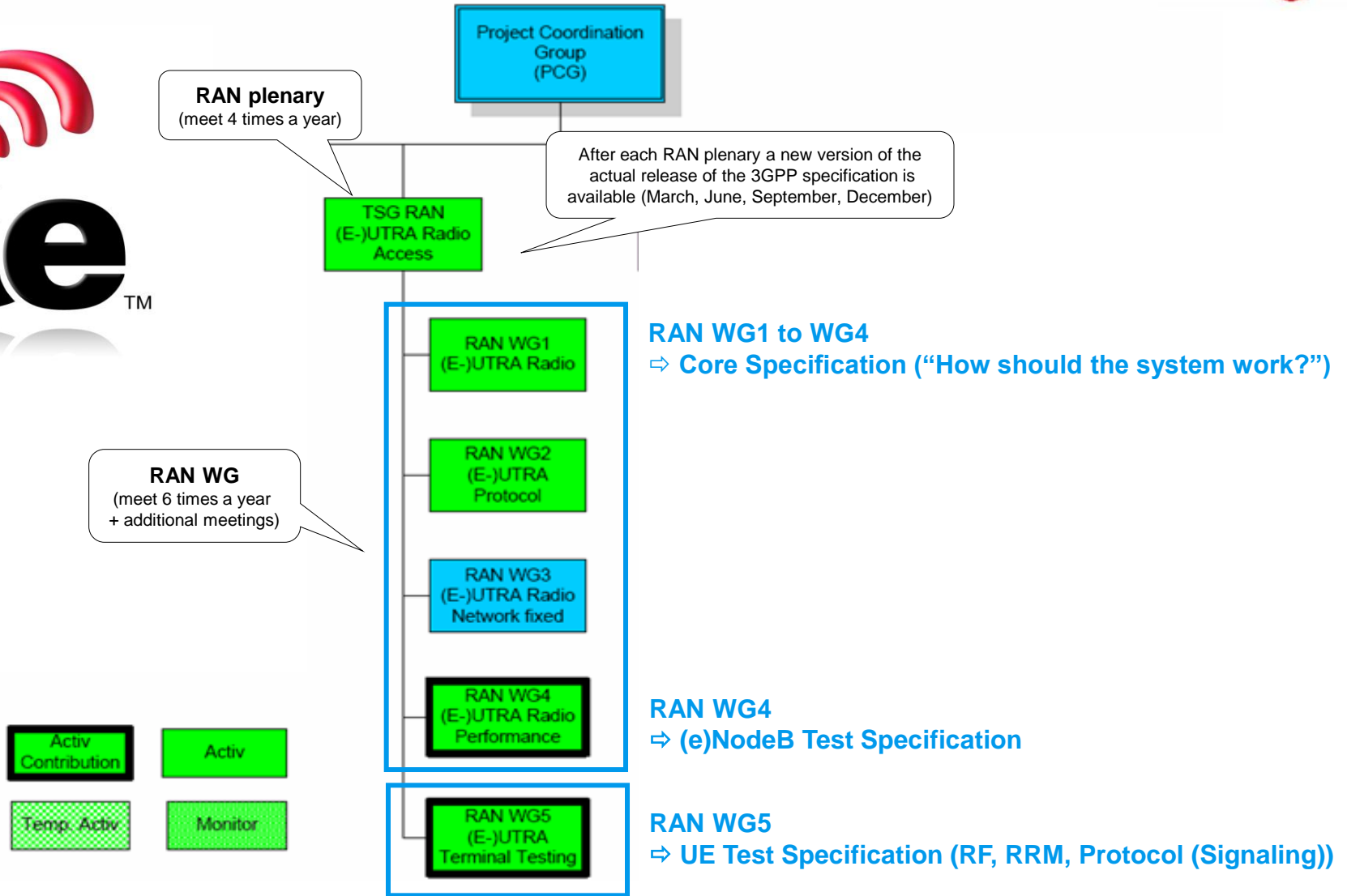
# LTE Testing Methodologies

## Conformance Testing

- RF radiated spurious emissions
- RF conducted tests
- Radio Resource Management (RRM)
- Signaling (protocol) tests
- InterRAT tests
- (U)SIM card interface tests
- A-GPS tests
- IMS CC (IP Multimedia Subsystem Call Control)
- Application Enabler (AE) tests (MMS, VT, PoC, Java, SUPL, Browsing))
- Audio tests
- CTIA / Over the air (OTA) tests



# LTE standardization



## I RAN1 to RAN4 (core specification)

- I LTE Release 8 and 9 is fully stable from a core specification point of view
- I Focus has shifted towards LTE-Advanced (3GPP Release 10) and beyond

## I RAN5 (terminal testing)

- I High workload on finalizing UE test specification as required for Release 8
- I High numbers of Change Requests (CRs) in recent months, but decreasing
- I Focus shifts to Release 9 testing

# Who are members of PTCRB ?



## Companies and organizations consisting of:

- I Mobile network operators**
- I Terminal manufacturers**
- I Chipset manufacturers**
- I Test laboratories (observers)**
- I Test equipment vendors (observers)**
  
- I GCF: responsible for frequency bands mainly used in Europe + Asia**
- I PCTRB: responsible for frequency bands mainly used in the Americas**

# Why conformance testing?



# 3GPP Conformance Certification

## Prioritization

### I Standards bodies have prioritized protocol and RF test cases (TCs) which are considered as most important for UE interoperability,

#### I RF / RRM TCs are selected from 3GPP TS 36.521-1 / 36.521-3,

- FDD: 55 RF and 55 RRM TCs , TDD: 56 RF and 45 RRM TCs,
- These TCs are covered with the following work items,
  - WI-080 E-UTRA RF Rel-8 FDD,
  - WI-090 E-UTRA RF Rel-8 TDD,

#### I 4 priority groups exist selecting signalling TCs from 3GPP TS 36.523-1,

- Signalling priority group #1 and #2 contain 208 signalling TCs, respectively,
- In total 467 test cases, i.e. 259 test cases in priority group #3 and #4,
- These test cases are covered with the following work items,
  - WI-081 E-UTRA Protocol Rel-8 FDD,
  - WI-082 EPC Protocol Rel-8 FDD,
  - WI-091 E-UTRA Protocol Rel-8 TDD,
  - WI-092 EPC Protocol Rel-8 TDD,

### I Separate WI's for each band to aid Certification Entry Criteria tracking,

- I FDD - Bands 1, 3, 4, 5, 7, 11, 12, 13, 14, 18, 20, 25,
- I TDD - Bands 38, 40 , 41

# 3GPP Conformance Certification

## UE LTE RF testing according to 3GPP TS 36.521-1

### I Tx characteristic (section 6),

- I Transmit power,
  - Maximum UE output power, Maximum Power Reduction (MPR), Additional MPR, configured UE transmitted output power,
- I Output power dynamics,
  - Minimum output power, Transmit OFF power, ON/OFF time mask, power control,
- I Transmit Signal Quality,
  - Frequency error, EVM vs. subcarrier, EVM vs. symbol, LO leakage, IQ imbalance, In-band emission, spectrum flatness,
- I Output RF spectrum emissions,
  - Occupied bandwidth, Spectrum Emission Mask (SEM), Adjacent Channel Leakage Power Ratio (ACLR), spurious emission band UE coexistence,
- I Transmit Intermodulation,

### I Rx characteristics (section 7),

- I Reference sensitivity level, Maximum input level, Adjacent channel selectivity (ACS), Blocking characteristics, Spurious response, Intermodulation characteristics, Spurious emissions,

### I Performance requirements (section 8),

- I Demodulation of PDSCH (FDD/TDD),
  - Single antenna, transmit diversity (2x2, 4x2), open/closed loop spatial multiplexing (2x2, 4x2),
- I Demod. of PCFICH/PDCCH (FDD/TDD),
  - Single antenna, transmit diversity,
- I Demodulation of PHICH,
  - Single antenna, transmit diversity,
- I Demodulation of PBCH,

### I Reporting of CQI/PMI (section 9),

- I CQI reporting under AWGN and fading conditions, single and multiple PMI reporting.

# 3GPP Conformance Certification

## RRM testing according to 3GPP TS 36.521-3

### I EUTRAN RRC\_IDLE state mobility,

- I EUTRAN cell selection,
- I EUTRAN reselection,
- I EUTRAN to UTRA cell reselection,
- I EUTRAN to GSM cell reselection,
- I EUTRAN to HRPD cell reselection,
- I EUTRAN to 1xRTT cell reselection,

### I EUTRAN RRC\_CONNECTED state mobility,

- I EUTRAN Handover,
- I EUTRAN Handover to other RATs,
- I EUTRAN Handover to non-3GPP RATs,

### I RRC Connection mobility control,

- I RRC connection re-establishment,
- I Random Access,

### I Timing and signaling characteristics (FDD and TDD),

- I UE transmit timing, timing accuracy,
- I UE timing advance,
- I UE transmit timing, test for radio link out-of-synch, in-synch, out-of-synch in DRX, in-synch in DRX,

### I UE measurement procedures,

- I Measure quality of EUTRA link and other technologies,

### I Measurement performance requirements,

- I RSRP, RSRQ.

# 3GPP Conformance Certification

Protocol conformance testing acc. to 3GPP TS 36.523-1

## I IDLE mode operations,

- I PLMN selection, cell selection and reselection, closed-subscriber group cells (= femto-cell),

## I MAC,

- I RACH, DL-SCH data transfer, UL-SCH data transfer, DRX operation, Transport Block Size (TBS) selection,

## I RLC,

- I Unacknowledged Mode, Acknowledged Mode,

## I PDCP,

- I Ciphering, Integrity protection, handover, discard,

## I Radio Resource Control (RRC),

- I Connection management process, RRC connection reconfiguration, Measurement control and reporting, Inter-RAT handover, Radio Link Failure, UE capability transfer,

## I Evolved Packet System (EPS) mobility management,

- I Common and specific procedures (attach, detach, tracking area update), connection management procedures (service request, paging), NAS security,

## I EPS session management,

- I EPS bearer context modification, deactivation, UE requested PDN connectivity and disconnect.



# LTE Testing Methodologies

## Performance

### I Data Throughput

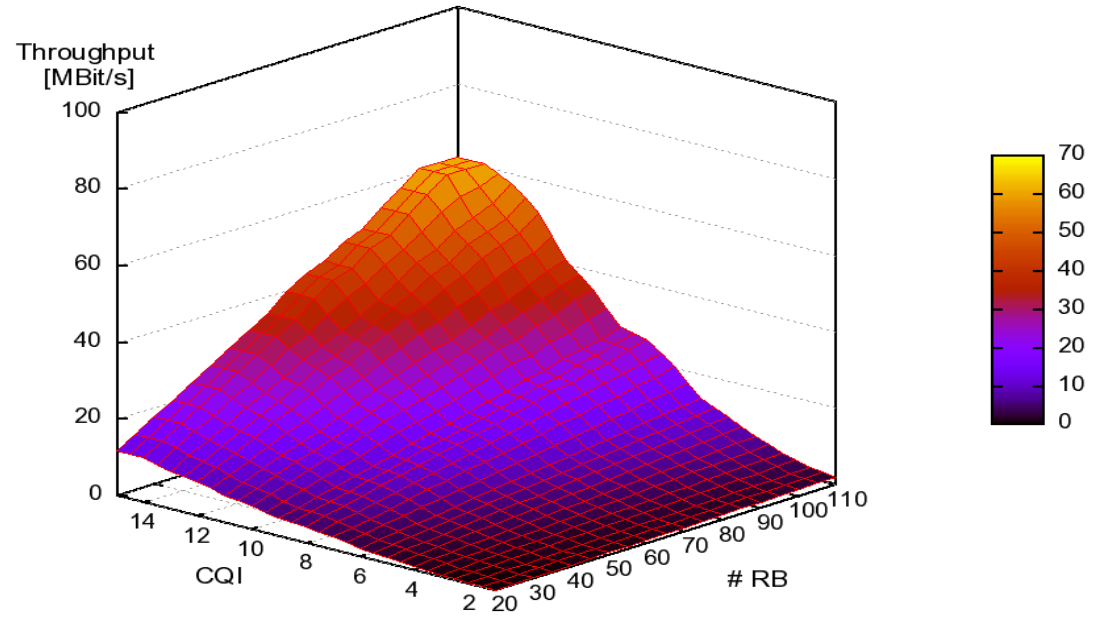
- I MIMO, SISO
- I Fading Conditions
- I AWGN
- I IPv4 vs IPv6
- I QoS, Multiple PDN

### I Receiver Sensitivity (BLER)

### I VoLTE / Audio Quality

### I Video Quality

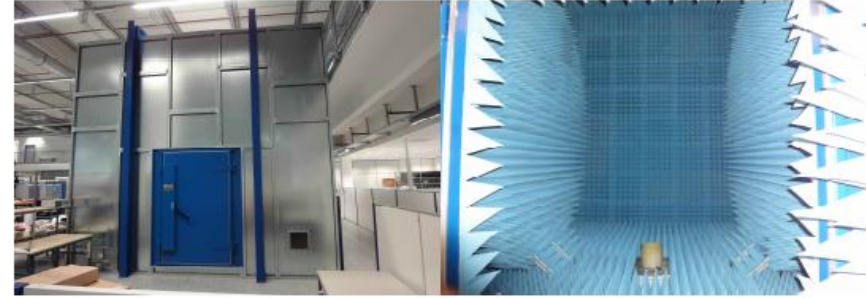
LTE Network Layer Throughput as function of CQI level and RB Setup



# LTE Testing Methodologies

## OTA Radiated Performance

- I Test Specs - CTIA OTA v3.0
- I Carrier Specific OTA Radiated Performance
- I Phantom head and hands to simulate influences of user during test
- I UE transmitter total radiated power (TRP)
- I UE complex antenna pattern measurements
- I UE receiver total isotropic sensitivity tests (TIS)



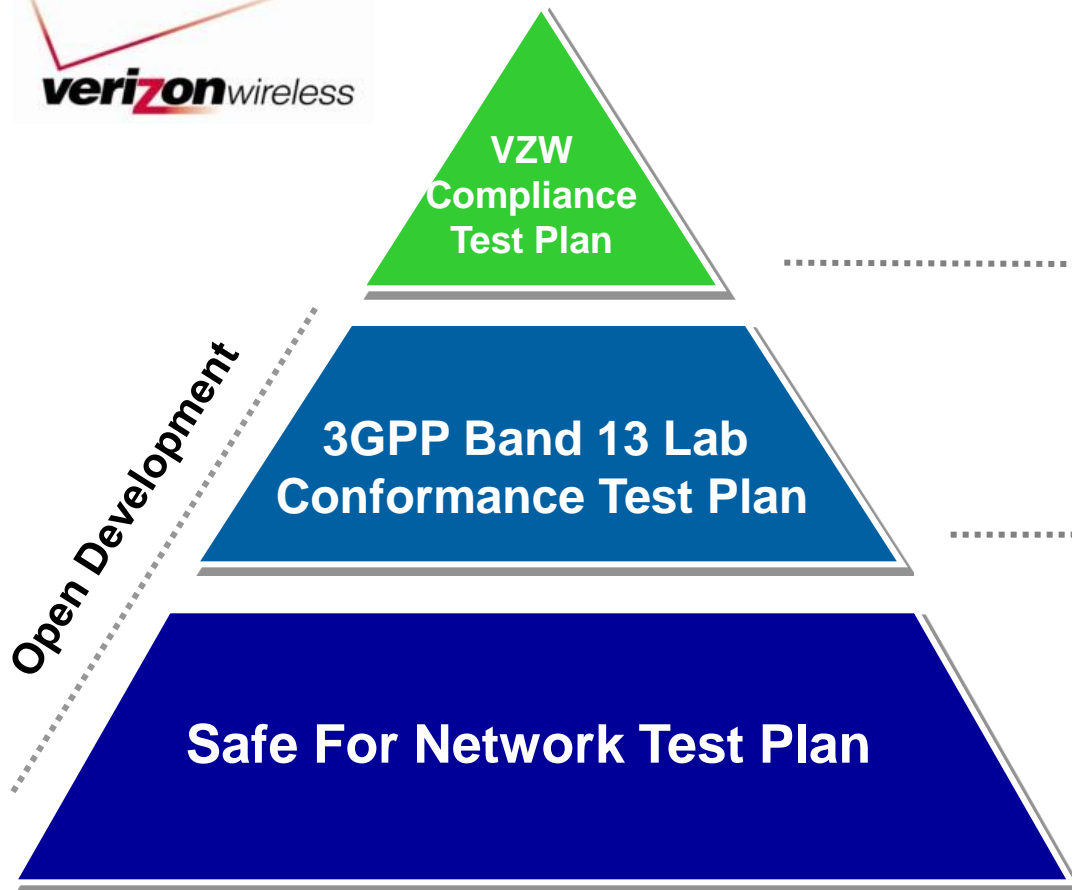
# LTE Testing Methodologies

## Network Operator Specific

- **Network Operators design own test cases specific to their network**
  - Supplementary RF (700 MHz – eg ATSC)
  - Data Throughput
  - Data Retry
  - UICC
  - IP Multimedia Subsystem (IMS)
    - SMS, Voice
  - Global Mode System Selection
  - Inter Radio Access Technology Handovers
  - ...

# LTE Testing Methodologies

## Carrier Specific



- GMSS T1, GMSS T2, SVD GMSS
  - InterRAT Performance, SVD InterRAT
  - eHRPD Conformance
  - LBS Performance
  - SVD Conformance & Performance
  - MM SMS, eHRPD SMS
  - MM OTADM
  - MM Device UICC (USIM, ISIM) Interaction
  - VoLTE
  - Video Performance
- 
- LTE Over the Air Radiated Performance
  - Data Throughput
  - OTADM
  - VOLTE (VoIP, Audio Quality, Audio & Video Performance)
- 
- 3GPP Band 13 RF and RRM Conformance
  - LTE Supplementary RF Conformance
  - 3GPP Band 13 Signaling Conformance
  - LTE Supplementary Signaling Conformance
  - Data Retry Test Plan
  - SMS Test Plan
  - Device UICC (USIM, ISIM) Interaction

**Over 20 different test plans (outside of conformance testing) !**

# LTE Testing Methodologies

## Carrier Specific



Scope	Count
R42 LTE Mobility Management Procedures	16
R43 LTE RRC and Encryption	27
R44. LTE Intra-RAT Mobility: LTE-ACTIVE MM State	15
R45. LTE Inter-RAT Mobility: LTE-ACTIVE MM State	40
R51. CSFB	67
R52. LTE Data Performance	78
R53 SON ANR	28
R50. 3G LTE User Experience Data Performance Test	18
R54 AMR-MM	25

**Over 1500 test cases (outside of conformance testing)!**

# Multimode Testing

## I 24 prio1 test cases / 4 prio2 test cases covering (TS 36.521-3)

- I interRAT LTE→WCDMA: handover test cases
- I interRAT WCDMA→LTE: first release (reselection test cases)
- I interRAT LTE→GSM: first release (reselection test case, event-triggered reporting)
- I interRAT LTE→1xEVDO: reselection test cases

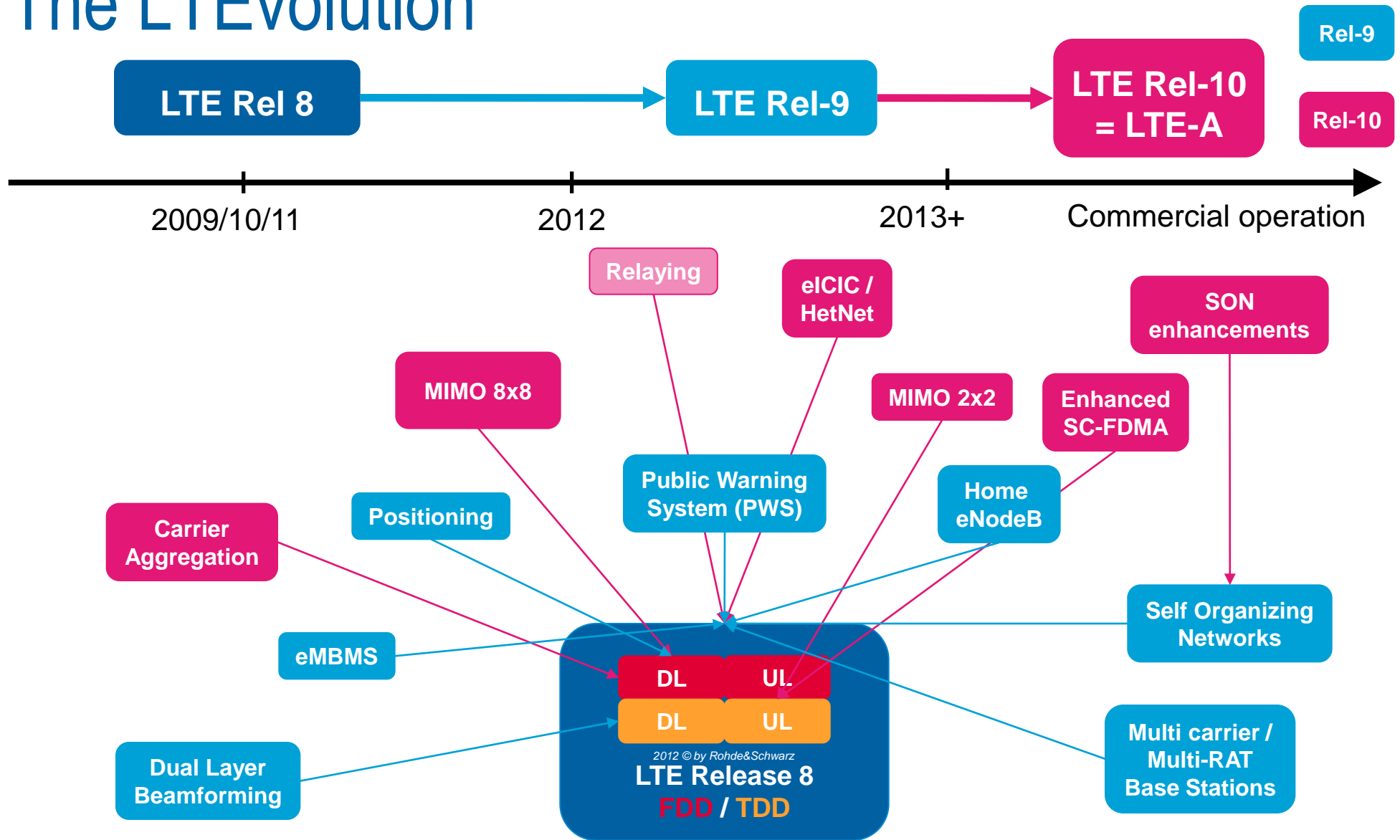
## I Protocol Conformance and Network operator test plans

- I 100's of tests covering every inter RAT permutation
  - Different technologies
  - Idle and Active Modes
  - SRVCC, CSFB

# LTE Rel 9 / 10



# The LTEvolution





# LTE / LTE-Advanced

The innovation platform for the next decade

The LTE eco system  
has developed fast  
based on strong drivers.

Test challenges remain

Research and  
Standards



2004/5

2006/7

Prototype  
development

2008/9

Development  
& Trials



2009/10

Commercial  
products and  
networks

2011/12

You are  
here!

2013/14

Significant  
deployment

# LTE-Advanced (Rel-10)

## 3GPP RAN#54 (Dec 9, 2011) – Completion Level Overview



Feature		Core Part (RAN1-4)	Performance Part (RAN4)	UE Conformance Tests Aspects (RAN5)
Rel-10	Carrier Aggregation for LTE	100%	100% (70%)	3% (0%)
	Enhanced Downlink Multiple Antenna Transmission for LTE	100%	85% (70%)	
	UL multiple antenna transmission for LTE (4 Tx moved to Rel-11)	100%	100%	
	Relays for LTE <sup>1)</sup>	100%	40% (30%)	
	Enhanced ICIC for non-CA based deployments of heterogeneous networks for LTE	100%	80% (70%)	
	Multi-standard radio BS RF requirements for non-contiguous spectrum deployments	100%	100%	-
	SON enhancements	100%	-	-
	Further enhancements for eMBMS	100%	-	

<sup>1)</sup> Not yet completed REL-10 RAN4 core aspects were taken over into WI LTE\_Relay2-Core at RAN #52 and REL-10 performance part was completely moved to REL-11 LTE\_Relay2-Perf.

# LTE-Advanced

## Protocol Conformance

2012 Tasks	Release	TC number	RAN WI	Schedule
LTE new TC	Rel-8/Rel-9	50	LTE_UEConTest_SIG	Q1-Q4
IMS emergency call	Rel-9	39	IMS_EMER_GPRS_EPS_UE ConTest	Q1-Q2
LTE Positioning	Rel-9	22	LCS_LTE_UEConTest	Q1-Q3
LTE Home eNB enhancements	Rel-9	13	EHNB-LTE_UEConTest	Q1-Q2
SSAC	Rel-9	3	SSAC_UEConTest	Q2
LTE MBMS	Rel-9	9	MBMS_LTE-UEConTest	Q1-Q2
LTE PWS (CMAS)	Rel-9	10	LTE_PWS-UEConTest	Q3-Q4
LTE MDT	Rel-10	10	MDT_UMTSLTE_UEConTest	Q4

# LTE/LTE-A Frequency Bands (FDD/TDD)

E-UTRA Operating Band	Uplink (UL) operating band	Downlink (DL) operating band
	$F_{UL\_low} - F_{UL\_high}$ [MHz]	$F_{DL\_low} - F_{DL\_high}$ [MHz]
1	1920 – 1980	2110 – 2170
2	1850 – 1910	1930 – 1990
3	1710 – 1785	1805 – 1880
4	1710 – 1755	2110 – 2155
5	824 – 849	869 – 894
6	830 – 840	875 – 885
7	2500 – 2570	2620 – 2690
8	880 – 915	925 – 960
9	1749.9 – 1784.9	1844.9 – 1879.9
10	1710 – 1770	2110 – 2170
11	1427.9 – 1447.9	1475.9 – 1495.9
12	699 – 716	729 – 746
13	777 – 787	746 – 756
14	788 – 798	758 – 768
17	704 – 716	734 – 746
18	815 – 830	860 – 875
19	830 – 845	875 – 890
20	832 – 862	791 – 821
21	1447.9 – 1462.9	1495.9 – 1510.9
22	3410 – 3490	3510 – 3590

E-UTRA Operating Band	Uplink (UL) operating band	Downlink (DL) operating band
	$F_{UL\_low} - F_{UL\_high}$ [MHz]	$F_{DL\_low} - F_{DL\_high}$ [MHz]
23	2000 – 2020	2180 – 2200
24	1626.5 – 1660.5	1525 – 1559
25	1850 – 1915	1930 – 1995

E-UTRA Operating Band	Downlink (DL) / Uplink (UL) operating band
	$F_{low} - F_{high}$ [MHz]
33	1900 – 1920
34	2010 – 2025
35	1850 – 1910
36	1930 – 1990
37	1910 – 1930
38	2570 – 2620
39	1880 – 1920
40	2300 – 2400
41	2496 – 2690
42	3400 – 3600
43	3600 – 3800



# LTE-Advanced

## RF Conformance

### I Devices shall be tested against all bands supported

- I FDD1, FDD3, FDD4, FDD5, FDD7, FDD11, FDD12, FDD13, FDD14 FDD17, FDD18, FDD20, FDD25, FDD26, TDD38, TDD40, TDD41

### I Not all LTE bandwidths must be tested however

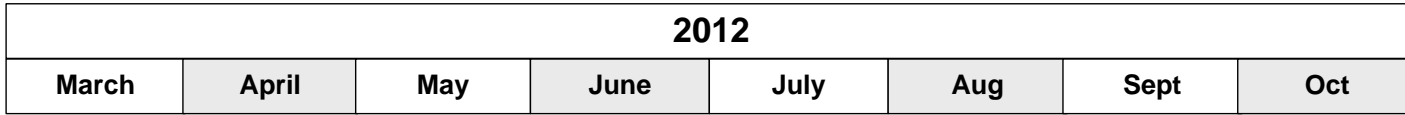
- I Eg. Mainly 10MHz only for sections 8, 9

	Automated Test Times (Hours)	Manual Test Times (Hours)
LTE RF Conformance (36.521-1)	Ave 24 per Band *	40 per Band *

- I \* test times do not include temperature and voltage extreme conditions (double test times)

# LTE FDD/TDD Release 9 RF Test Cases

3GPP 36.521-1 Version 10.0



**Beamforming TestCases**

- 8.3.2.1.1\_1 TDD PDSCH Single-layer Spatial Multiplexing on Antenna Port 5
- 8.3.2.1.2 TDD PDSCH Single-layer Spatial Multiplexing on Antenna Port 7 or 8 without a Simultaneous Transmission
- 8.3.2.1.3 TDD PDSCH Single-layer Spatial Multiplexing on Antenna Port 7 or 8 with a Simultaneous Transmission
- 8.3.2.2.1 TDD PDSCH Dual-layer Spatial Multiplexing

**Frequency Bands support**

FDD 1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 17, 18, 19, 20, 21, (24), 25, 26  
TDD 38, 39, 40, 41

**Baseline:**

March-2011(R9)

8.7.1.1 FDD Sustained Data Rate Performance

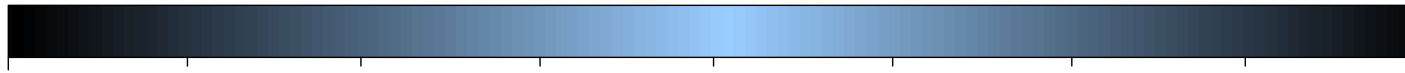
8.7.2.1 TDD Sustained Data Rate Performance

**Frequency Bands support**

FDD 1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 17, 18, 19, 20, 21, 23 (?), (24), 25, 26  
TDD 38, 39, 40, 41

**Baseline:**

March-2011(R9)



Mar 12

4

5

6

7

8

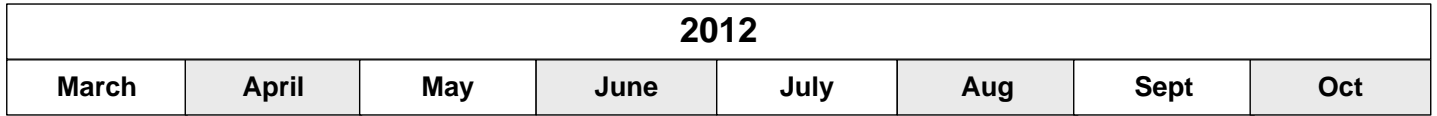
9

10

Oct 12

# LTE FDD/TDD Release 9 RF Test Cases

3GPP 36.521-1 Version 10.0



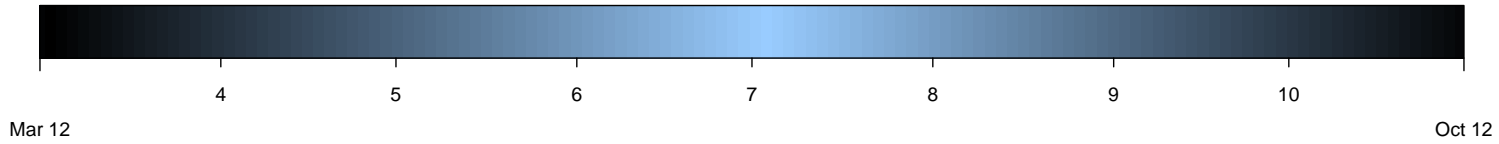
6.6.3.2\_1 Spurious emission band UE co-existence

8.2.1.1.1\_1 FDD PDSCH Single Antenna Port Performance  
 8.2.1.2.1\_1 FDD PDSCH Transmit Diversity 2x2  
 8.2.1.1.1\_1 FDD PDSCH Single Antenna Port Performance  
 8.2.1.2.1\_1 FDD PDSCH Transmit Diversity 2x2  
 8.2.1.2.2\_1 FDD PDSCH Transmit Diversity 4x2  
 8.2.1.4.1\_1 FDD PDSCH Closed Loop Multi Layer Spatial Multiplexing 2x2  
 8.2.1.4.2\_1 FDD PDSCH Closed Loop Multi Layer Spatial Multiplexing 4x2  
 8.4.1.2.1\_1 FDD PCFICH/PDCCH Transmit Diversity 2x2  
 8.4.1.2.2\_1 FDD PCFICH/PDCCH Transmit Diversity 4x2  
 8.5.1.2.1\_1 FDD PHICH Transmit Diversity 2x2  
 8.5.1.2.2\_1 FDD PHICH Transmit Diversity 4x2  
 9.4.2.1.1\_1 FDD PMI Reporting – PUSCH 1-2 (Multiple PMI)

8.2.2.1.1\_1 TDD PDSCH Single Antenna Port Performance  
 8.2.2.2.1\_1 TDD PDSCH Transmit Diversity 2x2  
 8.2.2.2.2\_1 TDD PDSCH Transmit Diversity 4x2  
 8.2.2.4.1\_1 TDD PDSCH Closed Loop Multi Layer Spatial Multiplexing 2x2  
 8.2.2.4.2\_1 TDD PDSCH Closed Loop Multi Layer Spatial Multiplexing 4x2  
 8.4.2.2.1\_1 TDD PCFICH/PDCCH Transmit Diversity 2x2  
 8.4.2.2.2\_1 TDD PCFICH/PDCCH Transmit Diversity 4x2  
 8.5.2.2.1\_1 TDD PHICH Transmit Diversity 2x2  
 8.5.2.2.2\_1 TDD PHICH Transmit Diversity 4x2  
 9.4.2.1.2\_1 TDD PMI Reporting – PUSCH 1-2 (Multiple PMI)

**Frequency Bands support**  
 FDD 1, 2, 3, 4, 5, 7, 8, 9, 11, 12, 13, 14, 17, 18,  
 19, 20, 21, 23 (?), (24), 25, 26  
 TDD 38, 39, 40, 41

**Baseline:**  
 March-2011(R9)



# LTE-Advanced Carrier Aggregation

- I **Carrier aggregation in downlink only, two component carriers in uplink postponed to 3GPP Release 11.**
- I **Much more RF conformance testing required**
  - I for each band combination (BC 4, 17 for eg)
  - I for each low/mid/high freq combination
  - I for each cell bandwidth (5,10,20 MHz)

Inter band CA operating bands				
E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band	Downlink (DL) operating band	Duplex Mode
CA_1-5	1	1920 – 1980 MHz	2110 – 2170 MHz	FDD
	5	824 – 849 MHz	869 – 894 MHz	

Intra band CA operating bands				
E-UTRA CA Band	E-UTRA Band	Uplink (UL) operating band	Downlink (DL) operating band	Duplex Mode
CA_1	1	1920 – 1980 MHz	2110 – 2170 MHz	FDD
CA_40	40	2300 – 2400 MHz	2300 – 2400 MHz	TDD



# Carrier aggregation (CA)

## Specification work (RAN4)

Title	Acronym	Band combination	800MHz	2GHz	2.5GHz	Work item	Work item rapporteur
LTE-A CA of Band 3 and Band 7	CA-B3_B7	High-High		X	X	RP-100669	TeliaSonera
LTE-A CA of Band 4 and Band 17	CA-B4_B17	High-Low	X	X		RP-101391	AT&T
LTE-A CA of Band 4 and Band 13	CA-B4_B13	High-Low	X	X		RP-101435	Ericsson (Verizon)
LTE-A CA of Band 4 and Band 12	CA-B4_B12	High-Low	X	X		RP-110135	Cox Communications
LTE-A CA of Band 20 and Band 7	CA-B20_B7	High-Low	X	X		RP-110403	Huawei (Orange)
LTE-A CA of Band 2 and Band 17	CA-B2_B17	High-Low	X	X		RP-110432	AT&T
LTE-A CA of Band 4 and Band 5	CA-B4_B5	High-Low	X	X		RP-110433	AT&T
LTE-A CA of Band 5 and Band 12	CA-B5_B12	Low-Low	X			RP-110372	US Cellular
LTE-A CA of Band 5 and Band 17	CA-B5_B17	Low-Low	X			RP-110434	AT&T
LTE-A CA of Band 38 (TD-LTE)	CA-B38	High			X	RP-110862	Huawei (CMCC)
LTE-A CA of Band 41 (TD-LTE)	CA-B41	High			x	RP-110673	Clearwire

# Carrier aggregation (CA)

Specification work (RAN4), cont'd.

Title	Acronym	Band combination	800MHz	2GHz	2.5GHz	Work item	Work item rapporteur
LTE-A CA of Band 20 and Band 3	CA-B20_B3	Low-High	X	X		RP-111212	Vodafone
LTE-A CA of Band 20 and Band 8	CA-B20_B8	Low-Low	X			RP-111213	Vodafone
LTE-A CA of Band 3 and Band 5	CA-B3_B5	Low-Low	X			RP-111339	SK Telecom
LTE-A CA of Band 7	CA-B7	High-High			X	RP-111356	China Unicom
LTE-A CA of Band 1 and Band 7	CA-B1_B7	High-High		X	X	RP-111357	China Telecommunication
LTE-A CA of Band 4 and Band 7	CA-B4_B7	High-High		X	X	RP-111358	Rogers Wireless
LTE-A CA of Band 25 and Band 25	CA-B25_25	High-High		X		RP-111371	Sprint

# LTE testing is a never ending cycle

Operator Test  
Plans

New Band  
Classes

3GPP Baseline  
Changes

New Features  
VoLTE, Video

OEM firmware  
updates

