LTE-Advanced: 3GPP Release 12 and 13

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KEYSIGHT TECHNOLOGIES

Agenda

LTE book 2nd Edition new LTE-Advanced App Note

Wireless evolution 1990 – 2015

Spectrum aspects and Carrier Aggregation

Release 12 status and highlights

Release 13 status and highlights

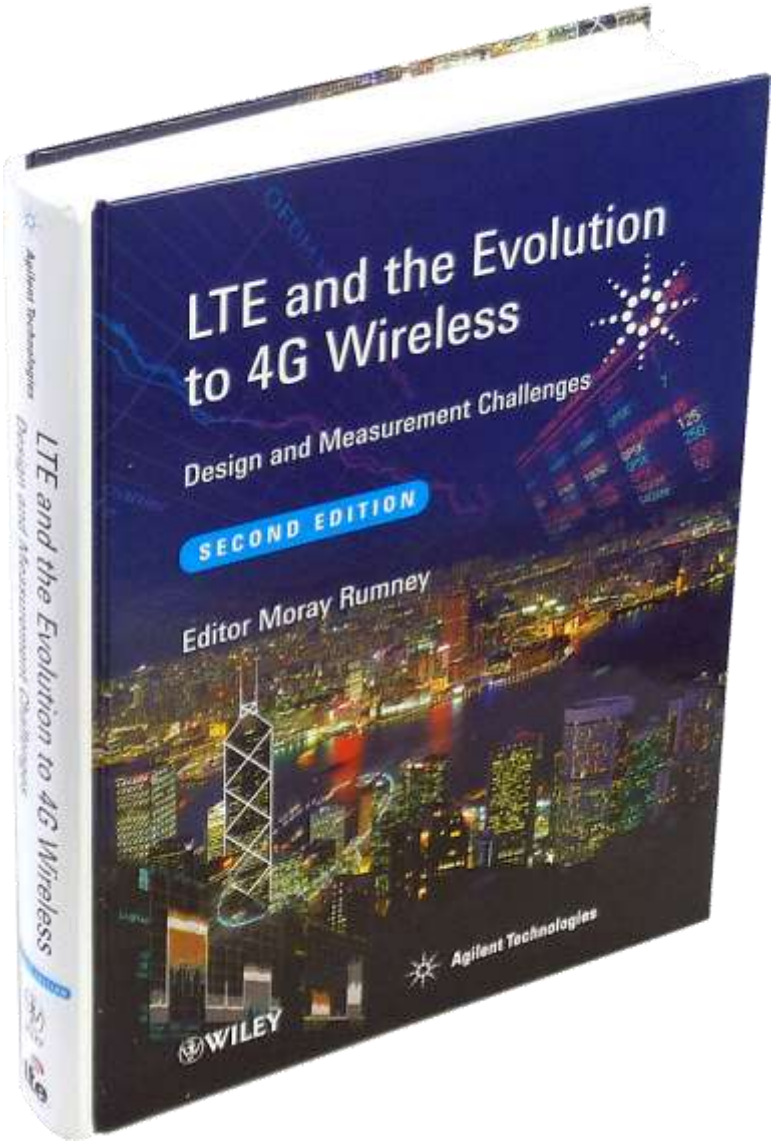
Summary

Reference materials

- Complete list of Rel-12 & 13 RAN study/work items
- Navigating the 3GPP specs

Second edition of LTE book

The second edition of Keysight's LTE book published in 2013 includes new material for Releases 10, 11 and 12.

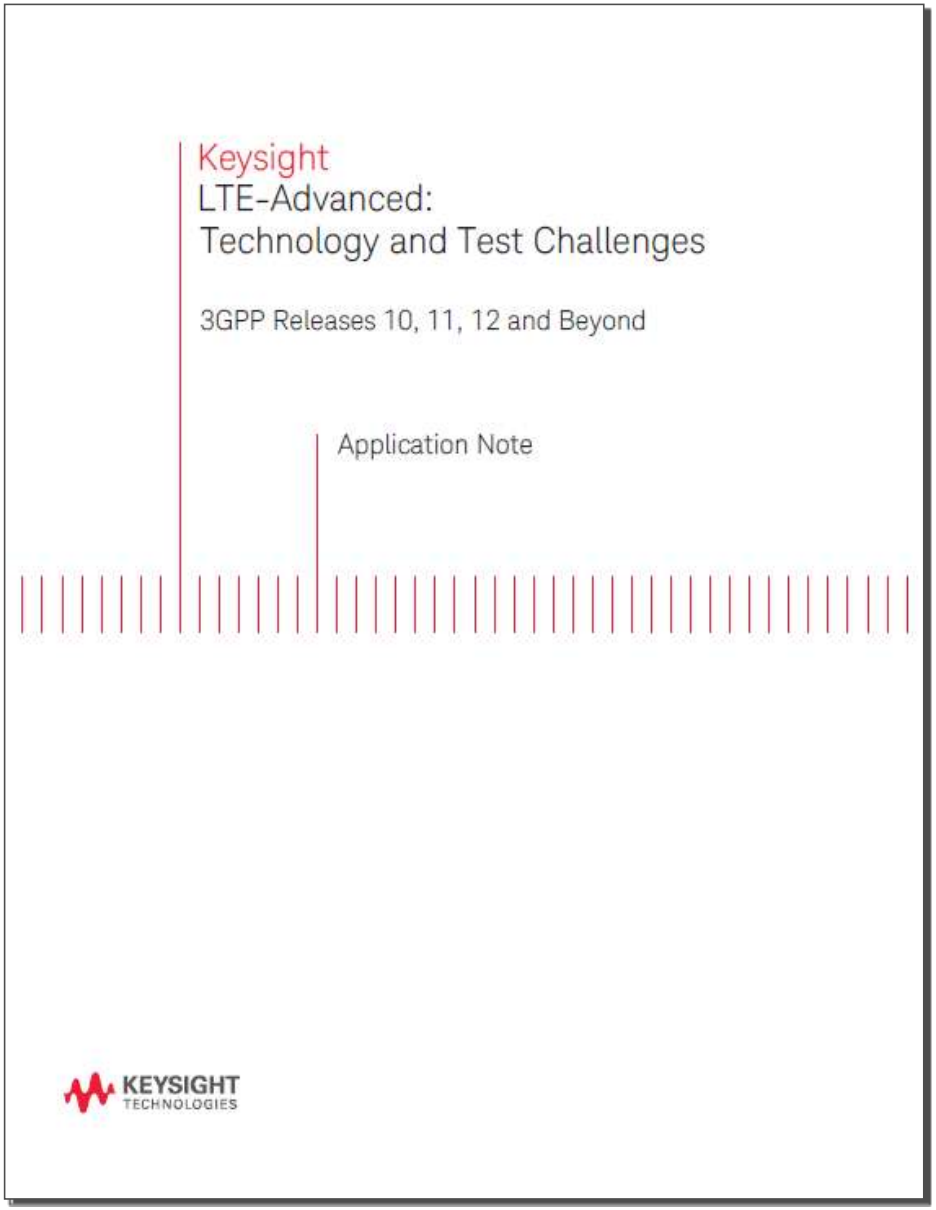


www.keysight.com/find/ltebook

New LTE-Advanced Application Note

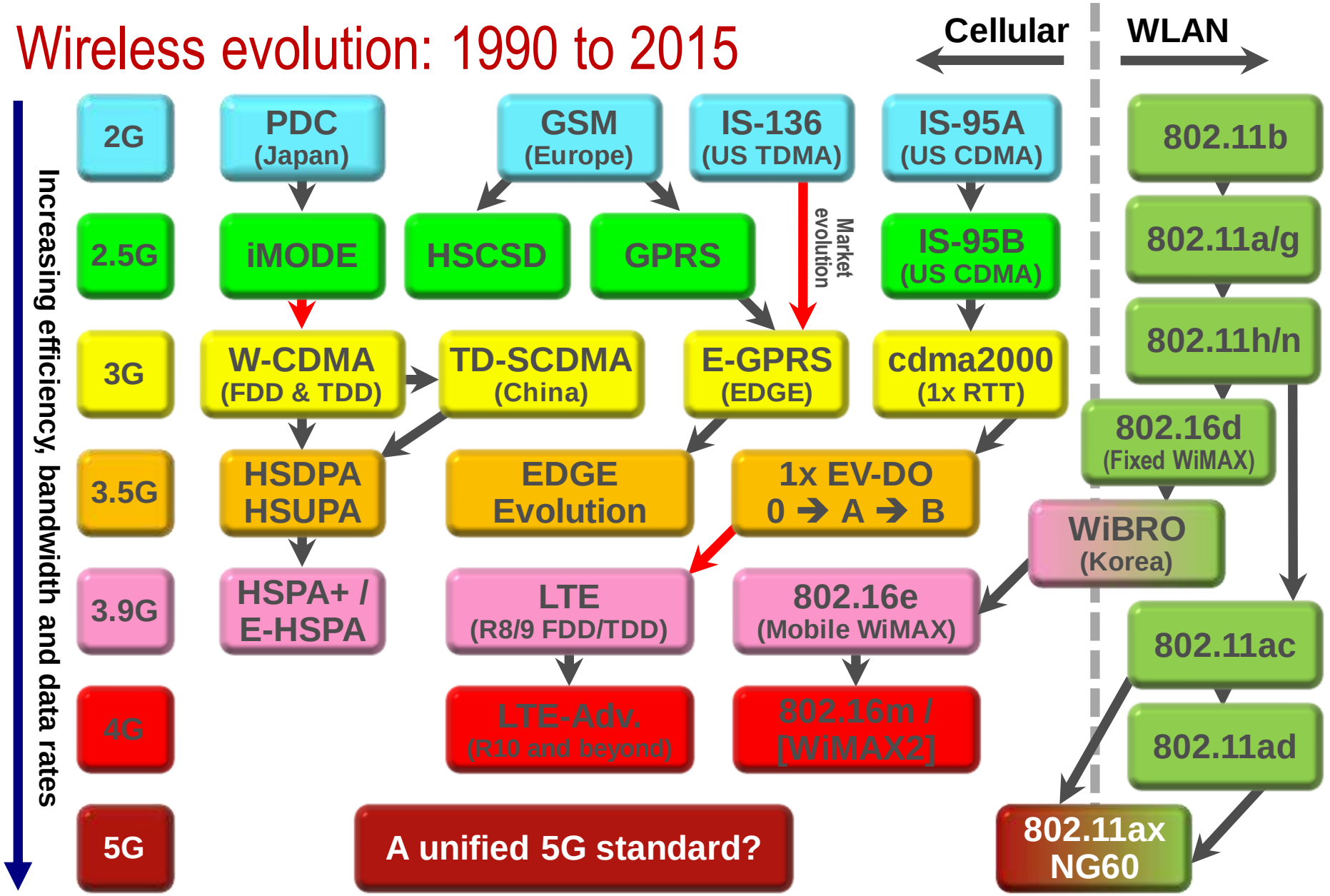
A new LTE-Advanced Application Note has been published.

This covers LTE-A up to June 2014



http://literature.cdn.keysight.com/litweb/pdf/5990-6706EN.pdf

Wireless evolution: 1990 to 2015



UMTS Long Term Evolution

1999

2016

Release	Stage 3: Core specs frozen	Main feature of Release
Rel-99	March 2000	UMTS 3.84 Mcps (W-CDMA FDD & TDD)
Rel-4	March 2001	1.28 Mcps TDD (aka TD-SCDMA)
Rel-5	June 2002	HSDPA
Rel-6	March 2005	HSUPA (E-DCH)
Rel-7	Dec 2007	HSPA+ (64QAM DL, MIMO, 16QAM UL). LTE & SAE Feasibility Study, Edge Evolution
Rel-8	March 2009	LTE Work item – OFDMA air interface SAE Work item – New IP core network UMTS Femtocells, Dual Carrier HSDPA
Rel-9	March 2010	Multi-standard Radio (MSR), Dual Carrier HSUPA, Dual Band HSDPA, SON, LTE Femtocells (HeNB) LTE-Advanced feasibility study, MBSFN
Rel-10	Sept. 2011	LTE-Advanced (4G) work item, CoMP Study Four carrier HSDPA
Rel-11	March 2013	CoMP, eDL MIMO, eCA, MIMO OTA, HSUPA TxD & 64QAM MIMO, HSDPA 8C & 4x4 MIMO, MB MSR
Rel-12	June 14 -> March 15	3DL CA, D2D, MTC, NAICS, Dual connectivity, small cells…
Rel-13	March 2016	LAA (LTE-U), 4 CA, >5 CA study, MIMO OTA, FD MIMO

3GPP workload

The scale of the work in 3GPP is formidable.

Looking just at the work of TSG RAN in 2014:

- 6 committees
- 4 to 8 meetings per year with ~900 attendees
- Over 26,000 technical documents submitted

This presentation will attempt to summarize Release 12 and the work to date in Release 13 – perhaps 50,000 documents!

There will only be time to discuss a few features but links and navigation help is provided at the end to facilitate more in-depth analysis

RAN work items / study items per release

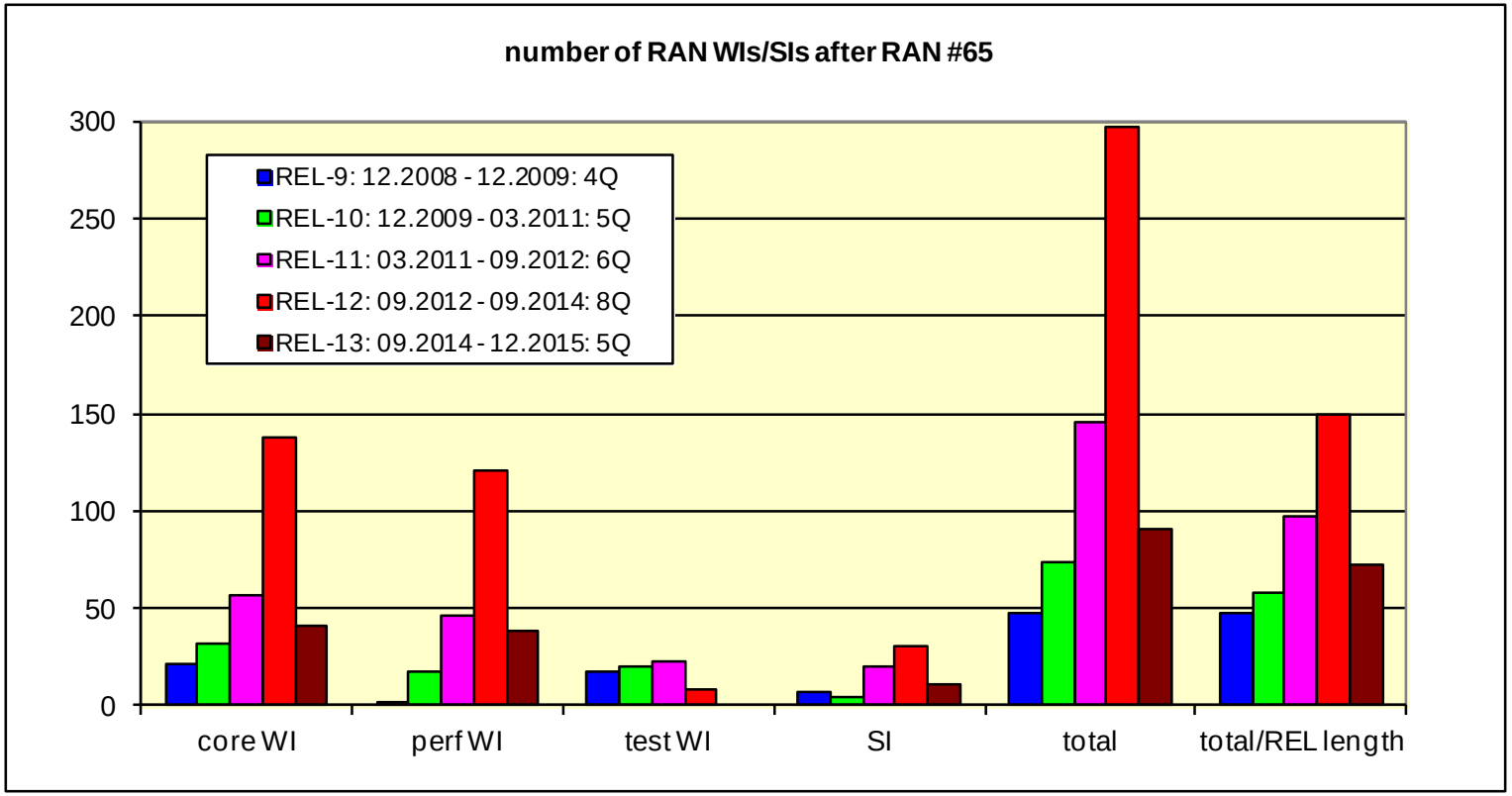


Fig. F-1: Number of all approved RAN work items (WI) and RAN study items (SI) (incl. already completed WIs/SIs) in the different releases after RAN #65

The above figure from the RAN #65 Sept. 2014 report indicates the increasing fragmentation of the 3GPP radio standards. Rel-13 is just starting but will be shorter than Rel-12. More than half the activity in Rel-12 is carrier aggregation.

The 3GPP Work Plan

The 3GPP work plan is the highest level summary of all the work going on in 3GPP covering the following technical specification groups:

- SA – System Aspects
- RAN – Radio Access Network
- CT – Core Network
- GERAN – GSM EDGE Radio Access Network

The work plan can be found at ftp://ftp.3gpp.org/Information/WORK_PLAN/

It is updated quarterly after the SA plenary meeting and comes in various forms but the spreadsheet is probably the most useful.

In order to limit scope, the remainder of this presentation will use the RAN work plan with a further focus here on LTE.

The 3GPP RAN Work Plan

The RAN workplan is also updated quarterly

The latest can be found here:

http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_66/Info_for_workplan/

To access earlier or future work plans substitute a different RAN meeting number e.g. for the next RAN meeting #67 in March 2015, change 66 to 67

http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_67/Info_for_workplan/

A tutorial on how to navigate the RAN work plan and other useful reference material on the 3GPP website like the change request database can be found at the end of this presentation.

Release 12 RAN status
Almost done…

Like Release 11, Release 12 has a very large number of mainly smaller new features, 327 to date:

- 283 LTE, 22 LTE & UTRA, 22 UTRA

Release 12 has been long, originally Sept 2012 to June 2014, but now extended to March 2015 (functional freeze date – no new items).

Most items are now closed (21 remain open). Half will close in March 2015 but some not till March 2016.

There are 73 items related to study or work on new features

- 31 Study items for feasibility of new work
- 38 new features (non CA), 24 with new performance requirements
- 4 performance-only requirements for features from earlier releases

The remaining items are for CA and test

- 114 CA combinations with 108 corresponding performance requirements
- 8 conformance tests to date (conformance tests always lag new features)

Release 12 highlights

The following topics will be covered in some detail

- Spectrum - New frequency bands and carrier aggregation
- CoMP
- Network-Assisted Interference Cancellation and Suppression (NAICS)
- 3D Channel models
- WLAN/3GPP interworking
- E-UTRA Small cell enhancements - Physical layer aspects
- Dual connectivity
- Group communications
- LTE Device to Device Proximity Services
- Machine Type Communications
- Active Antenna Array Systems (AAS)
- MIMO OTA
- LTE TDD-FDD joint operation

Classifying Rel-12 work and study items
73 work/study items (excluding test and CA)

There are three significant categories

- **Spectrum** (4) – Addition of new bands
- **Efficiency** (13) – inc. interference management
- **Small cell / femto / HetNet** (22) – Includes WLAN and SON

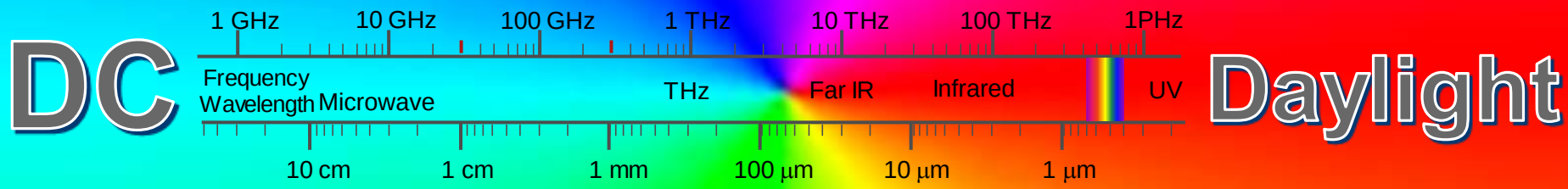
These three significant categories determine the capacity of networks

Plus a few significant topics that don't fit the above

- **D2D & MCC** (3) – Device to Device & Mission Critical Communications
- **MTC** (4) – Machine Type Communications
- **OTA** (2) – Radiated performance (antenna) aspects
- **Positioning** (5)

The remaining 20 items cover a variety of miscellaneous smaller features

Spectrum aspects



Release 12
Spectrum aspects

There was one study item and three work items related to Spectrum :

- Study on 2GHz FDD for UTRA and LTE in Region 1 (1980-2010MHz and 2170-2200MHz Bands)
- Core part: LTE in the US Wireless Communications Service (WCS) Band 30
- Core part: Introduction of LTE 450 MHz band in Brazil
- Core part: L-band for Supplemental Downlink in E-UTRA and UTRA

These led to the addition of three new FDD bands, 30, 31 and 32.

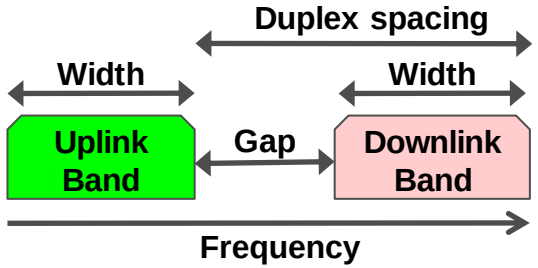
Band	Uplink MHz		Downlink MHz		Width	Duplex	Gap
30	2305	2315	2350	2360	10	45	35
31	452.5	457.5	462.5	467.5	5	10	5
32	DNA		1452	1496	44	-	-

Band 32 is the second supplemental downlink (SDL) band to be added

SDL is used for downlink-only carrier aggregation to improve data rates

LTE FDD Frequency bands Dec 2014

Band	Uplink MHz		Downlink MHz		Width	Duplex	Gap
1	1920	1980	2110	2170	60	190	130
2	1850	1910	1930	1990	60	80	20
3	1710	1785	1805	1880	75	95	20
4	1710	1755	2110	2155	45	400	355
5	824	849	869	894	25	45	20
6	830	840	865	875-	10	35	25
7	2500	2570	2620	2690	70	120	50
8	880	915	925	960	35	45	10
9	1749.9	1784.9	1844.9	1879.9	35	95	60
10	1710	1770	2110	2170	60	400	340
11	1427.9	1447.9	1475.9	1495.9	20	48	28
12	698	716	728	746	18	30	12
13	777	787	746	756	10	-31	21
14	788	798	758	768	10	-30	20
15*	1900	1920	2600	2620	20	700	680
16*	2010	2025	2585	2600	15	575	560
17	704	716	734	746	12	30	18
18	815	830	860	875	15	45	30
19	830	845	875	890	15	45	30
20	832	862	791	821	30	-41	11
21	1447.9	1462.9	1495.9	1510.9	15	48	33
22	3410	3490	3510	3590	80	100	20
23	2000	2020	2180	2200	20	180	160
24	1626.5	1660.5	1525	1559	34	-101.5	67.5
25	1850	1915	1930	1995	65	80	15
26	814	849	859	894	35	45	10
27	807	824	852	869	17	45	28
28	703	748	758	803	45	55	10
29	DNA		717	728	11	-	-
30	2305	2315	2350	2360	10	45	35
31	452.5	457.5	462.5	467.5	5	10	5
32	DNA		1452	1496	44	-	-



- Band overlaps exist for regional reasons
- Duplex spacing varies 30 to 799 MHz
- Downlink to uplink gap varies from 5 to 680 MHz
- Narrow duplex spacing and gaps make filter design hard to prevent the transmitter spectral regrowth leaking into the receiver (self-blocking)

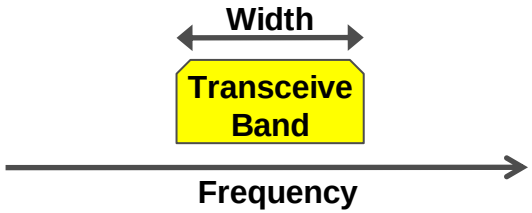
Bands 15 and 16 are specified by ETSI for use only in Europe

Bands 13, 14, 20 and 24 have reversed uplink downlink frequencies

Bands 29 and 32 are “supplemental downlink only” for carrier aggregation

LTE TDD Frequency bands Dec 2014

Band	Uplink MHz		Downlink MHz		Width
33	1900	1920	1900	1920	20
34	2010	2025	2010	2025	15
35	1850	1910	1850	1910	60
36	1930	1990	1930	1990	60
37	1910	1930	1910	1930	20
38	2570	2620	2570	2620	50
39	1880	1920	1880	1920	40
40	2300	2400	2300	2400	100
41	2496	2690	2496	2690	194
42	3400	3600	3400	3600	200
43	3600	3800	3600	3800	200
44	703	803	703	803	100



Summary of Carrier Aggregation work as at Dec 2014

Rel-10	3 new CA combinations
Rel-11	21 new CA combinations
Rel-12	114 new CA combinations including 3 DL
Rel-13	52 new CA combinations so far including 4 DL

There are now 190 CA combinations (8 for 4 DL) of the 42 bands

Four downlink CA is now in process with talk for Release 14 of "up to 32 carriers" (someone found a spare bit in the signalling…)

Every combination has the potential to require a new UE design to handle the filtering and PA requirements leading to higher cost, complexity and test

Other Keysight webcasts focussing on CA:

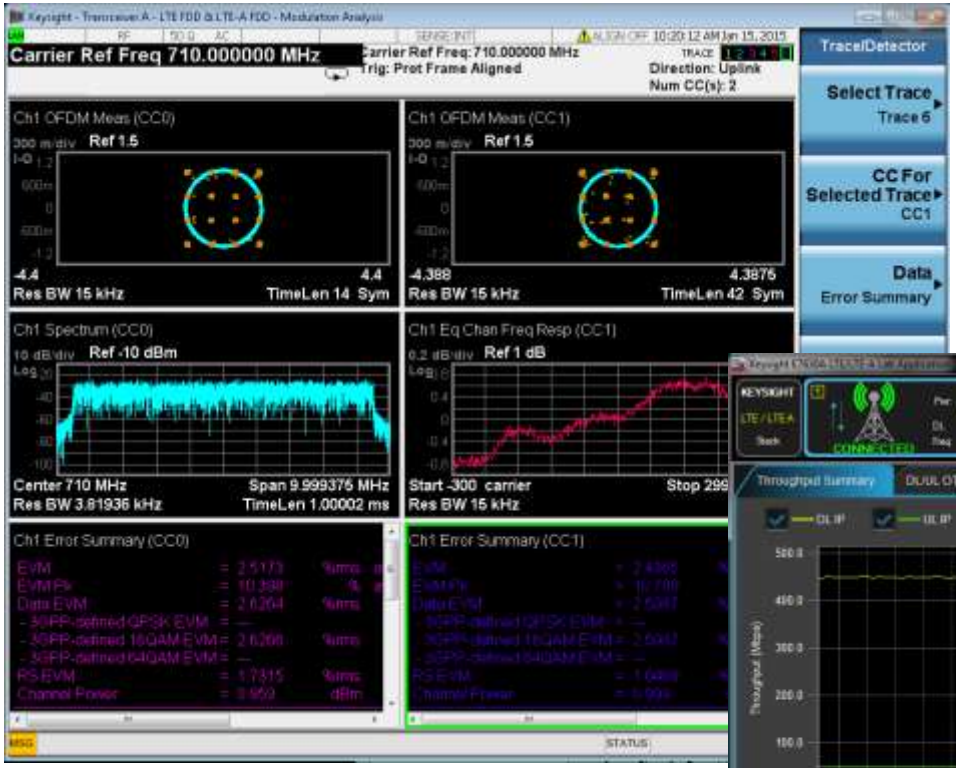
Carrier Aggregation: Fundamentals and Deployments Webcast

8x8 MIMO and Carrier Aggregation Test Challenges for LTE Webcast

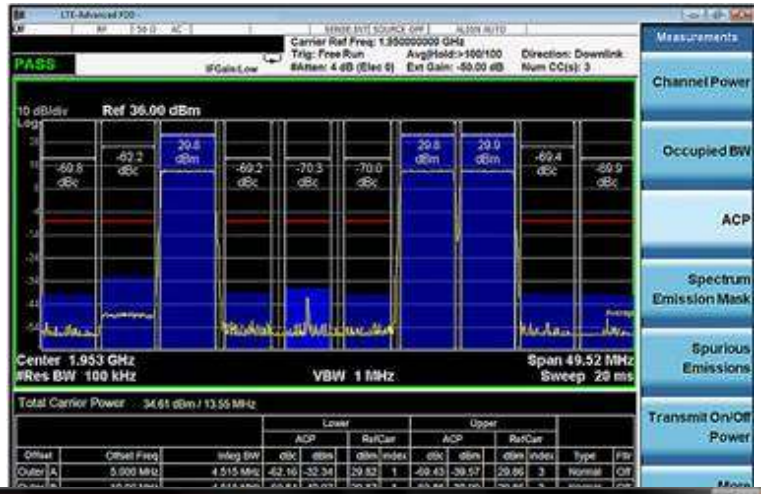
Validating LTE-A UE's: The increasing Importance of Data Throughput Performance

Some CA measurements

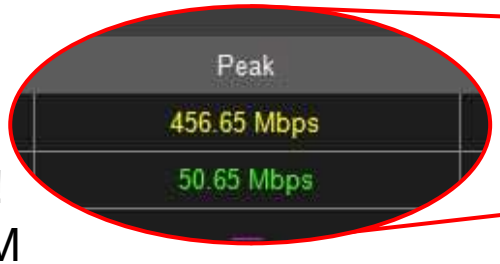
Inter-band EVM using MXA



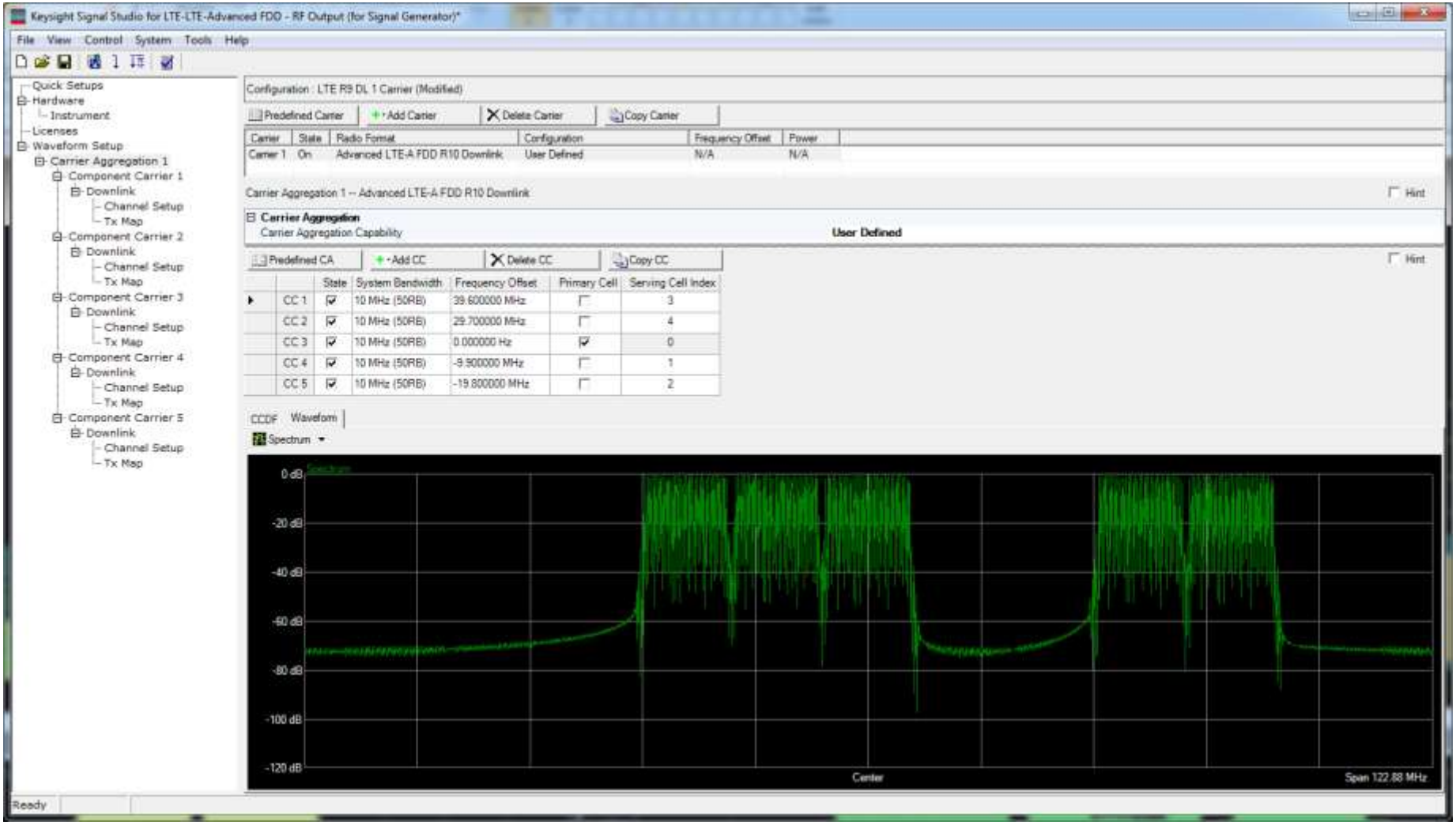
Intra-band 3 carrier using MXA



3 carrier
456 Mbps!
Using UXM



Five carrier intra-band signal generation example
Keysight Signal Studio for LTE



Five carrier inter-band signal analysis example Keysight 89600 Vector Signal Analyzer software

Release 12
Efficiency aspects

- **Study on CoMP for LTE with Non-Ideal Backhaul**
- **Core part: Inter-eNB CoMP for LTE**
- **Study and Core part: Network-Assisted Interference Cancellation and Suppression for LTE**
- **Study on 3D-channel model for Elevation Beamforming and FD-MIMO studies for LTE**
- Study and Core part: Further EUL enhancements
- Core part: Further Downlink MIMO Enhancement for LTE-Advanced
- Core part: Further Enhancements to LTE TDD for DL-UL Interference Management and Traffic Adaptation
- Core part: LTE Coverage Enhancements
- Perf. part: Performance Requirements of 8 Rx Antennas for LTE UL
- Perf. part: Performance requirements of interference cancellation and suppression receiver for SU-MIMO
- Perf. part: E-UTRA UE demodulation/Channel State Information (CSI) performance requirements for multiple Carrier Aggregation configurations

Spectral efficiency varies across the cell

Co-channel interference explains the fundamental behaviour of cellular systems sharing the same frequency between cells

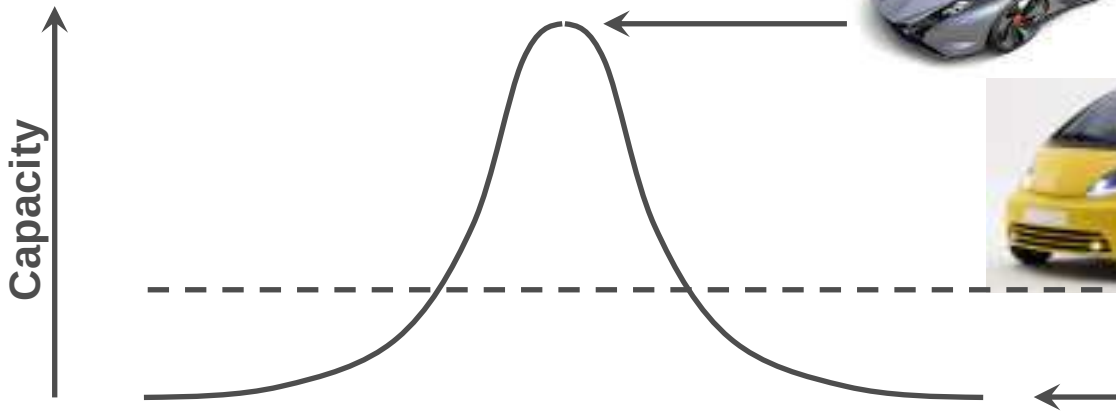
The effects can be mitigated but they are always present

Principle: Average performance cannot be derived or implied from peak performance.

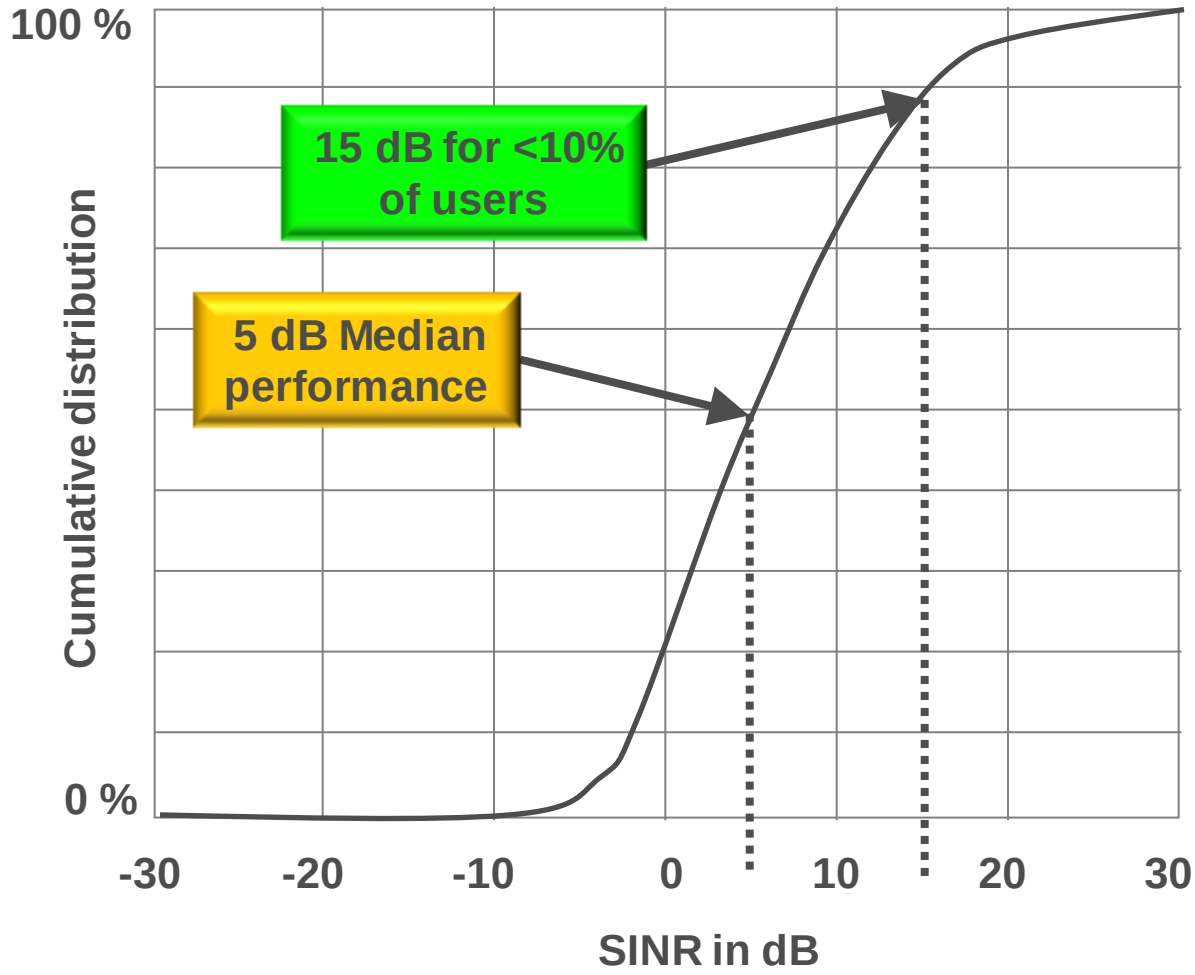
Peak performance (single car)

Average performance

Pedi-cab performance



Interference distribution in a typical loaded urban microcell



This plot shows a complimentary cumulative distribution function (CCDF) of the variation in SINR across a typical outdoor urban microcell cell

Principle: Highest performance requires high SINR - only available to a few users near the cell centre.

The “cell edge” can cover half the cell area.

Consequence of inter-cell interference across systems

Format \ Throughput	Occupied Bandwidth	Peak (Single user)	Average (10 users/cell)	Cell Edge (10 users/cell)	Raw Peak/ edge ratio*
GSM (1 slot) (10 users, freq. reuse = 4)	1 MHz	9.6 kbps	9.6 kbps	9.6 kbps	**1**
GPRS (4 slot)	4 MHz	81.6 kbps	50 kbps	36.2 kbps	**2.3**
EDGE (4 slot)	4 MHz	236.8 kbps	70 kbps	36.2 kbps	**6.5**
UMTS (Rel-99)	5 MHz	384 kbps	100 kbps	30 kbps	**12.8**
HSDPA (Rel-5)	5 MHz	3.6 Mbps	250 kbps	80 kbps	**45**
HSDPA (Rel-7)	5 MHz	42 Mbps	350 kbps	120 kbps	**350**
HSDPA (Rel-8)	10 MHz	84 Mbps	800 kbps	240 kbps	**350**
LTE (Rel-8) 4x4	20 MHz	300 Mbps	5.34 Mbps	1.6 Mbps	**187**
LTE-A (Rel-10) 4x4	20 MHz	600 Mbps	7.4 Mbps	2.4 Mbps	**250**

* Ratio can be reduced at expense of cell capacity with proportional fair scheduling and fractional frequency reuse

Study on 3D-channel model of Elevation Beamforming and FD-MIMO studies for LTE

Up to Release 11 MIMO was designed to support eNB antenna configurations capable of adaptation in azimuth only.

Interest now exists in exploiting the vertical domain.

To specify further methods of enhancing performance using 3D-beamforming or full-dimension MIMO (FD-MIMO), a new channel model is needed that will enable modelling in both the vertical and horizontal dimensions of the environment as well as at user locations in the network.

The study results can be found in TR 36.873.

Further study to asses potential performance gains is carried out in Release 13.

Managing interference: CoMP versus NAICS

CoMP - Coordinated Multipoint Transmission and Reception

and

NAICS - Network-Assisted Interference Cancellation and Suppression

are two techniques being designed to improve the performance of LTE at the cell edge where inter-cell interference is at its worst

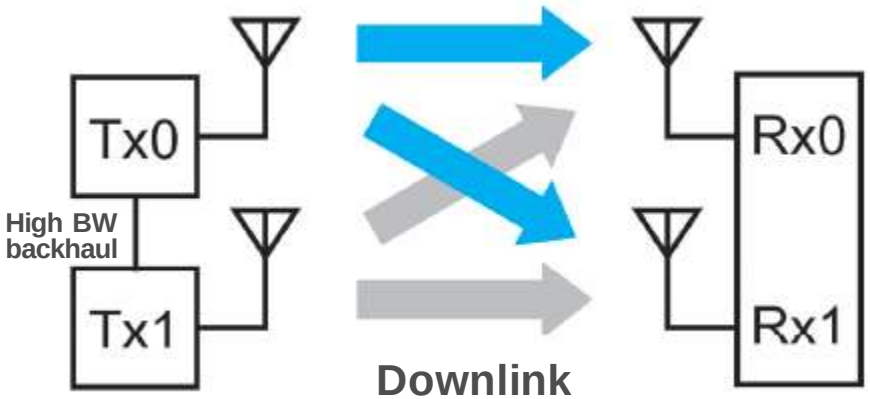
Although they are targeting the same issue they take completely different approaches

CoMP is largely backwards compatible, NAICS requires changes to the UE limiting its use to future releases

CoMP started in Rel-10 5 years ago, NAICS started three years later.

CoMP – soft handover meets MIMO

Traditional MIMO
co-located transmission



Downlink
Coordinated Multipoint

In CDMA systems, at the cell edge the UE would typically be receiving signals from two of more base stations and soft combining the result

- Good for single-user performance, not for cell capacity

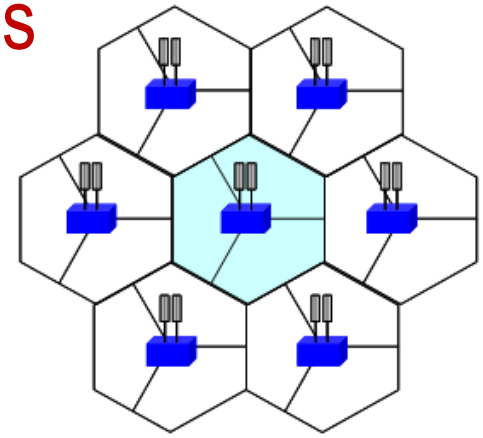
Due to use of OFDMA, LTE has no soft handover and has more complex DL interference

CoMP uses beamforming from non co-located cells to optimize cell edge signal quality

This requires tight synchronization and near zero-latency high bandwidth symbol-level backhaul between the transmitting nodes

Simulated gains are around10 % – 30%, with up to 80% in exceptional TDD conditions

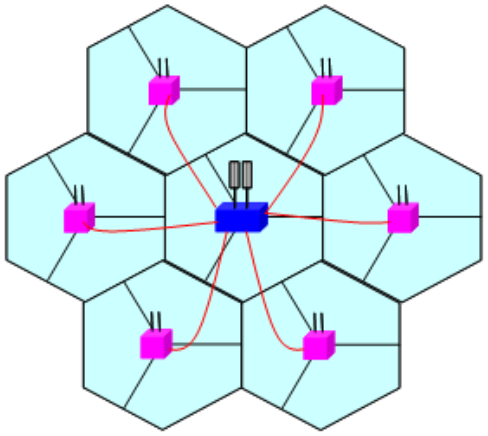
CoMP deployment scenarios TR 36.819



eNB

Coordination area

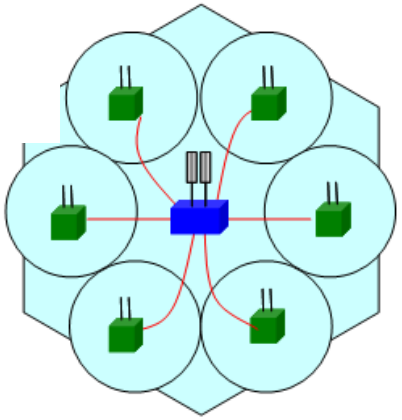
Scenario 1: Homogenous inter-site



High Tx power RRH

Optical fiber

Scenario 2: Homogenous with high power RRH



eNB

Low Tx power RRH (Omni-antenna)

Optical fiber

Scenario 3/4: Low power RRH within macrocell

CoMP techniques Release 11

Downlink Joint Processing (JP)

- Joint Transmission (JT) - a form of spatial multiplexing that takes advantage of de-correlated radio links. Data is simultaneously transmitted from multiple points to the UE with precoding to optimize reception
- Dynamic Point Selection (DPS) / muting - UE data is available at all points but is only transmitted from one point based on dynamic selection in time and frequency. DPS and JT can be combined.

Downlink Coordinated scheduling and beamforming (CS/CB)

- UE data transmitted from one point in the CoMP cooperating set but user scheduling and beamforming decisions are made across all points in the cooperating set. CS/CB can be combined with JP

Uplink Joint reception (JR)

- The UE uplink is jointly received at some or all of the cooperating set of eNB

Uplink Coordinated scheduling and beamforming (CS/CB)

- User scheduling and precoding selection decisions are made with coordination among points corresponding to the cooperating set. Data is intended for one point only.

CoMP
Release 12 and beyond

The work on CoMP continues in Release 12 with a study into non-ideal backhaul

- This is a critical factor influencing the potential for gains since bandwidth and latency restrictions in the backhaul can significantly limit performance

In addition there is a work item in Release 13 on enhanced inter-eNB CoMP signalling

Study on Network-Assisted Interference Cancellation and Suppression for LTE (NAICS)

The study item "Network Assisted Interference Cancellation and Suppression“ in TR 36.966 evaluated advanced interference cancellation (IC) and interference suppression (IS) receivers

Performance with and without network assistance was considered with a view to the impact on complexity

Comparison was against the interference rejection combiner receiver of Rel-11 (LMMSE-IRC)

Conclusion was that some network assistance or coordination reduces receiver complexity

Blind detection of some parameters is acceptable in certain cases.

A follow-on work item was created to define assistance parameters

Network-Assisted Interference Cancellation and Suppression for LTE (NAICS)

Following the study in TR 36.866 a NAICS WI was created

The assistance parameters identified as desirable for blind detection are

- Presence or absence of interference
- Transmission modes (TM)
- For DMRS-based TMs: DMRS ports, modulation order, Virtual cell ID, nSCID, Cell ID, CRS ports, and MBSFN pattern
- For CRS-based TMs: PMI, RI, modulation order, Cell ID, CRS ports, and MBSFN pattern, ρ_A
- Control Format Indicator (CFI)- if not coordinated and required by receiver implementation

The intention is to target a unified performance requirement for the NAICS receivers, including requirements covering both DMRS and CRS.

No performance should be lost compared to LMMSE-IRC receivers

Release 12
Small cell / femto HetNet

- Study on Passive InterModulation (PIM) handling for UTRA & LTE Base Stations
- Study on UMTS Heterogeneous Networks
- Study on CRS Interference Cancellation for Homogenous Deployments for LTE
- Study on next-generation SON for UTRA and LTE
- Study and Core part: LTE-HRPD (High Rate Packet Data in 3GPP2) inter-RAT SON
- **Study and Core part: WLAN/3GPP Radio Interworking**
- Study on Scenarios and Requirements of LTE Small Cell Enhancements
- Study on Small Cell Enhancements for E-UTRA and E-UTRAN – Physical-layer Aspects
- Study on Small Cell Enhancements for E-UTRA and E-UTRAN – Higher-layer aspects
- **Core part: E-UTRA Small cell enhancements - Physical layer aspects**
- Core part: Carrier based HetNet ICIC for LTE
- Core part: Further enhancements for H(e)NB mobility-Part 3
- Core part: New Carrier Type for LTE
- Core part: RAN aspects for SIPTO at the Local Network
- Core part: Increasing the minimum number of carriers for UE monitoring in UTRA and E-UTRA
- Core part: UMTS Heterogeneous Networks enhancements
- Core part: Hetnet Mobility Enhancements for LTE
- Core part: Further enhancements for HeNB mobility-X2-GW
- Core part: UMTS Mobility enhancements for Heterogeneous Networks
- **Core part: Dual Connectivity for LTE**

Why cell size matters more than spectral efficiency

Attribute \ Cell Type	Iridium Satellite	Rural	Urban macro	Urban micro	Pico	Femto	Wi-Fi Hotspot
Coverage	Worldwide (outdoor)	Rural	Urban	Urban	Metro	Home/ Metro	Home/ Metro
Mobility	Perfect	V Good	V Good	Good	Fair	Nomadic	Nomadic
Cell radius	1500 km	30 km	3 km	300 m	30 m	10 m	10 m
Cell area km^2	7,700,000	2826	28	0.28	0.0028	0.0003	0.0003
Total cells	66	500 k	1 M	5 M	50 M	500 M	1 B
Total System capacity/MHz	40 Mbps	500 Gbps	1 Tbps	7.5 Tbps	75 Tbps	1500 Tbps	1000 Tbps
Capex/cell	$5 M	$250 k	$200 k	$50 k	$5 k	$200	$50
Opex/cell/year	$700 k	$25 k	$20 k	$10 k	$5 k	$50	$20
Efficiency bps/Hz	0.6	1.0	1.0	1.5	1.5	3	1 – 2.5
Data density Mbps/km^2/MHz	0.00000008	0.00035	0.035	3.5	350	10000	3000

Spectral efficiency is essentially constant, data density varies 37.5B : 1

WLAN/3GPP Radio Interworking

A study in TR 37.834 identified solutions for traffic steering to improve user experience of WLAN

Operators did not agree on the best solution therefore the work item will define two selection methods

- Access Network Discovery Selection Function (ANDSF)
  - Inter-system mobility policy (ISMP) – single internet access
  - Inter-system routing policy (ISRP) – multiple internet access
  - Discovery information – info about local networks
- RAN rules
  - An alternative for when ANDSF is not implemented in the evolved packet core (EPC) network

Studies on Scenarios and Requirements of LTE Small Cell Enhancements

For a considerable time the focus of RAN standardization activities has been on wider bandwidths and higher spectral efficiency

However, small cells (frequency reuse) has never been addressed strategically

- Many RAN features already exist to facilitate spectral reuse such as femtocells and heterogeneous networks but the propagation, mobility, interference, and backhaul needs of small cells are very different to the assumptions that were used to define the original heterogeneous model

Three studies covering general, physical and higher layer aspects were drafted in TR 36.932, 36.872 and 36.842 leading to a work item on physical layer aspects.

E-UTRA Small cell enhancements - Physical layer aspects

The study in the physical layer aspects in TR 36.872 recommended:

- Downlink 256 QAM for low mobility sparse indoor scenarios
- Reduced transition time for small cell on/off
- Efficient radio-interface-based inter-cell synchronization (network listening)

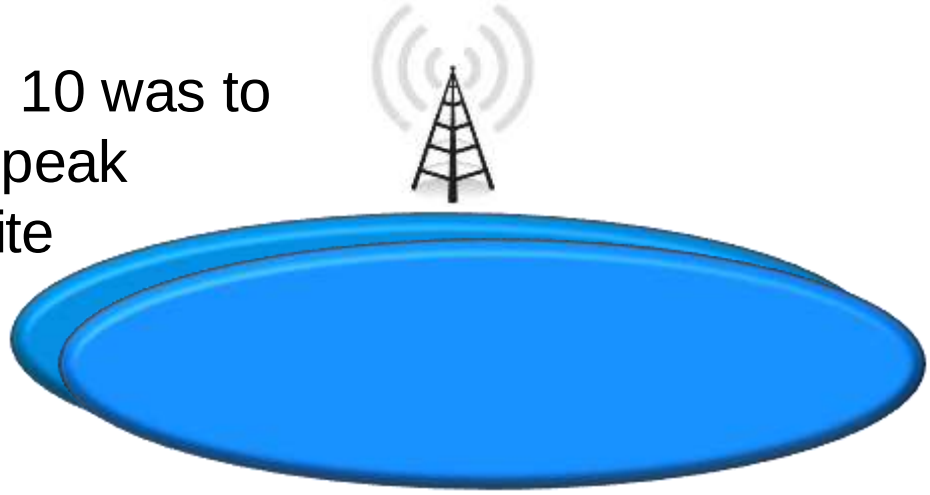
Downlink 256 QAM has now been specified which has much tighter EVM. From 36.104:

Table 6.5.2-1: EVM requirements

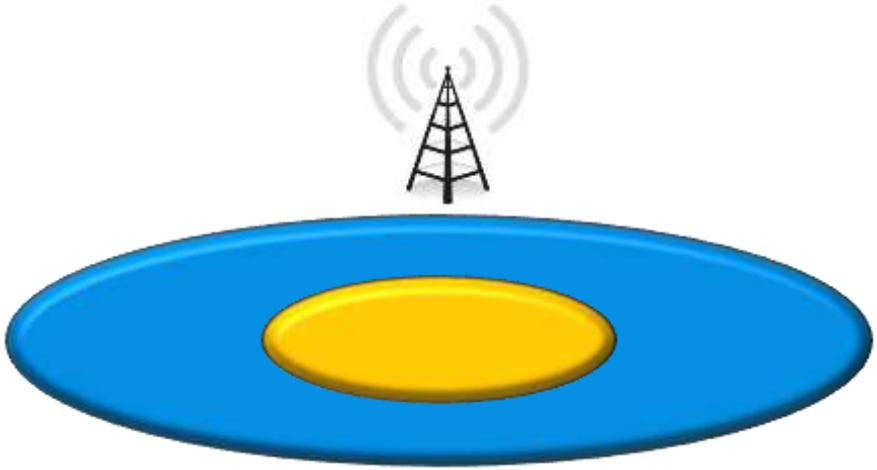
Modulation scheme for PDSCH	Required EVM [%]
QPSK	17.5 %
16QAM	12.5 %
64QAM	8 %
256QAM	3.5 %
NOTE: The EVM requirement for 256QAM applies to Home BS, Local Area BS, and Medium Range BS.	

Building the background to Dual Connectivity: Co-located CA

The original goal of CA in Release 10 was to increase the spectrum and hence peak data rate available from one cell site



Two carriers in the same band with very similar coverage area

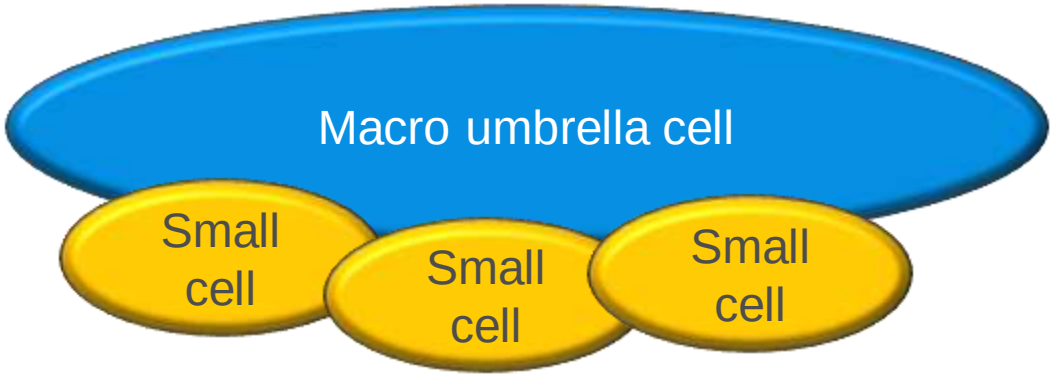


Two carriers of different frequencies showing different coverage areas

But when the 2nd carrier is at a very different frequency, the benefit of CA is limited to the centre of the cell which is not ideal

Building the background to Dual Connectivity: Inter-site CA

By allowing CA between sites it is possible to provide continuous CA coverage using a low frequency macro (umbrella) cell and local capacity using a higher frequency

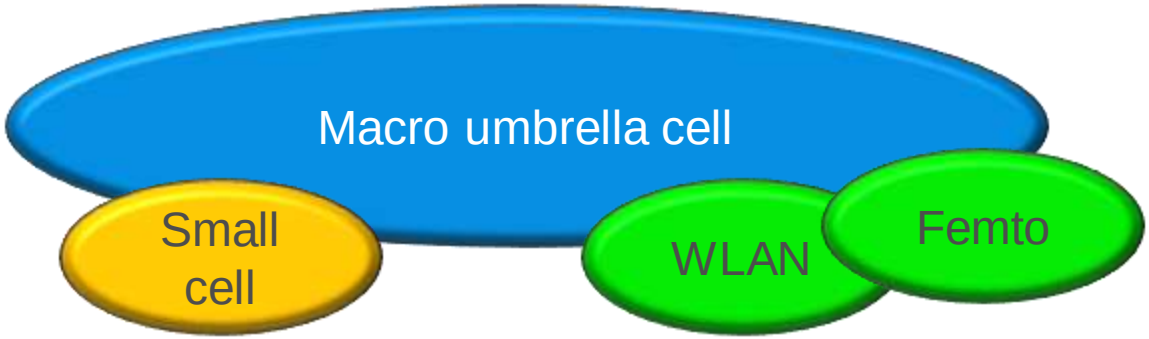


Inter-site CA still assumes ideal backhaul for low latency MAC layer cross-carrier scheduling

The separation of the sites means that enhancements are required at the physical layer including multiple timing advances

Dual connectivity
Release 12 - CA between sites with non-ideal backhaul

The ultimate flexibility is then achieved if CA is performed across sites and radio access technologies (RATs) and in particular with femtocells or WLAN, which may not have ideal backhaul



With non-ideal backhaul, MAC level cross-carrier scheduling is not possible so less tightly coupled solutions at higher layers are used. CA with WLAN also forces service-level integration e.g. Hotspot 2.0.

But dual connectivity CA between LTE and Wi-Fi may not be essential

WLAN higher layer integration vs. Dual Connectivity

Dual connectivity proposes a tightly coupled solution to extend CA to transmit one EPS bearer over more than one radio access link

The alternative builds on existing WLAN integration which allows only one access link per EPS bearer

The overheads of full CA with WLAN could be significant and would require modified L1/MAC for LTE and Wi-Fi

Whereas building on existing Rel-12 IP Flow mobility may be simpler and provide sufficient performance with no L1/MAC changes and integration.

The two links that are proposed to be aggregated are very unbalanced.

- The LTE link typically provides a larger latency and low throughput
- WLAN link is a low latency and high throughput.
- It is not uncommon to have on average about 3-4 HARQ retransmissions for a packet over the cellular link.

Wi-Fi is already nearly two orders of magnitude faster than cellular today. 801.11ac now reached 3.39 Gbps (4x MU-MIMO in 160 MHz)

Release 12
D2D & MCC, MTC

D2D / MCC - 3 study/work items

- Study on LTE Device to Device Proximity Services
- **Study on Group Communication for LTE**
- **Core part: LTE Device to Device Proximity Services**

MTC - 4 study/work items

- Study on Provision of low-cost MTC UEs based on LTE
- **Core part: Low cost & enhanced coverage MTC UE for LTE**
- Study on RAN aspects of Machine Type and other mobile data applications Communications enhancements
- Core part: RAN enhancements for Machine-Type and other mobile data applications Communications

New Technical Working Group
Mission critical communications - SA6

At SA Plenary #65 in September it was agreed to start a new TWG specifically to address the high level requirements of mission critical push to talk – PTT.

It will be some time before the high level requirements form SA6 come into RAN.

MC PTT is a very complicated subject which is why it warranted setting up anew committee to address.

Study on Group Communication for LTE

Group Communication is essential functionality for Land Mobile Radio/Private Mobile Radio and public safety systems.

Legacy systems such as Tetra, P25 and GSM-R have this

- For R-GSM see Voice Group Call Service TS 43.068

LTE has been adopted for next generation public safety in the US however LTE has no group Communication features

Stage 1 TS 22.468 “Group Communication System Enablers for LTE” has been drafted which led to the Stage 2 architectural study in TR 23.768.

This latest study further evaluated the suitability of LTE to meet the objectives developed in TR 23.768

Study on Group Communication for LTE

Study objectives

- Evaluate LTE air-interface when distributing the same content using unicast, to many public-safety -capable UEs taking into account the expected public safety use cases (including voice and multimedia communication);
- Evaluate ability of eMBMS or other mechanisms to provide group communication for public safety applications.

Requirements to consider

- Impact of user mobility to group communication performance;
- High level of availability of the radio connection for the public-safety -capable UE for group communication;
- Scalability of group communication solution;
- Need to support various media, as well as voice;
- Performance, such as Group Communication end-to-end setup time, service joining/acquisition time, and end to end delay for media transport.

The outcome of the study is in TR 36.868.

LTE Device to Device Proximity Services (LTE-ProSe) TR 36.843 (aka LTE-Direct, LTE-D)

LTE-ProSe represent a fundamentally new concept in device communications

The scope is in two main phases:

- Device to device discovery
- Device to device (D2D) communication

The application for the first phase is to enable devices to "express" their identity to other UE in the local area

- This can be used for a variety of purposes including location based advertising

The 2nd phase of D2D comms has many uses including public safety involving communication in the absence of a network

LTE Device to Device Proximity Services Deployment scenarios (TR 36.843)

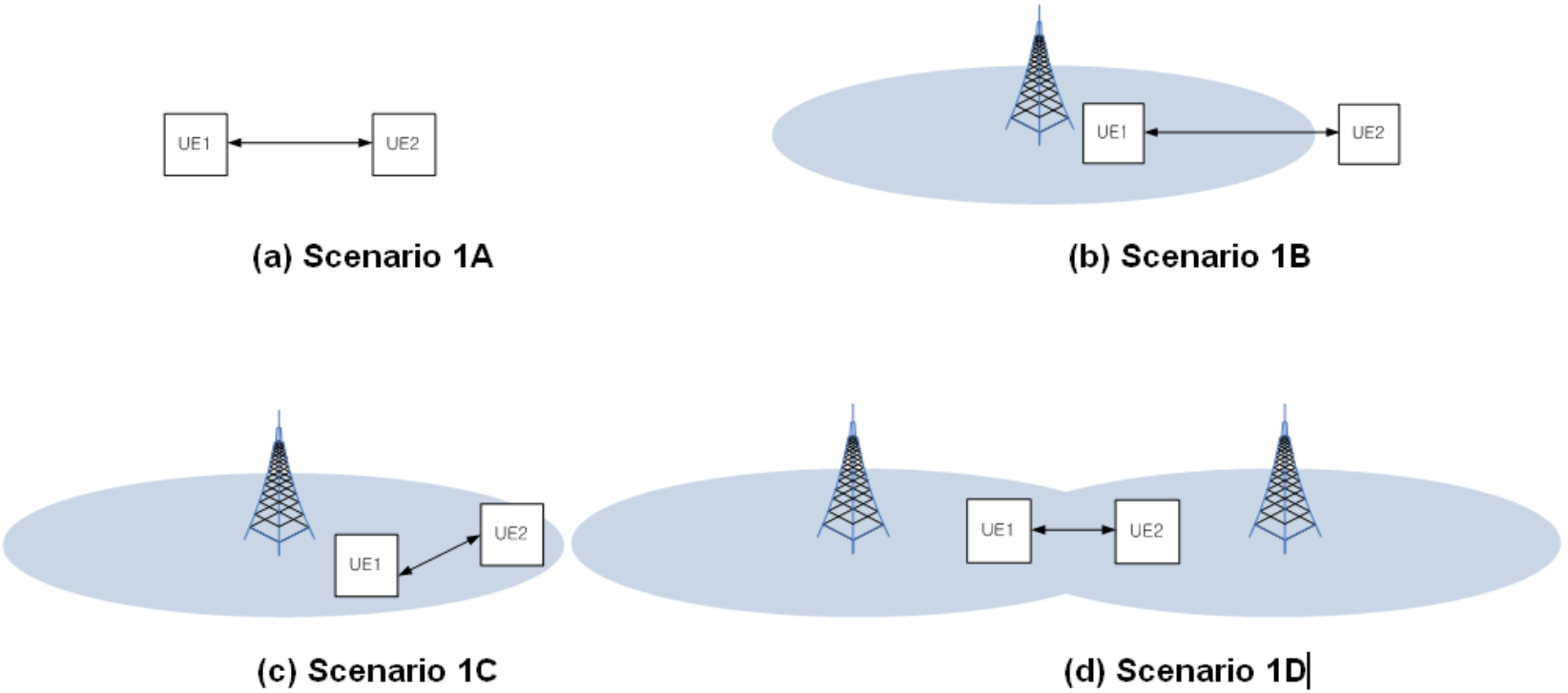


Figure 8.3.1-1 D2D Scenarios

Scenarios	UE1	UE2
1A: Out-of-Coverage	Out-of-Coverage	Out-of-Coverage
1B: Partial-Coverage	In-Coverage	Out-of-Coverage
1C: In-Coverage-Single-Cell	In-Coverage	In-Coverage
1D: In-Coverage-Multi-Cell	In-Coverage	In-Coverage

LTE Device to Device Proximity Services

Device discovery can be enabled by the eNB scheduling periods in the uplink when ProSe UE can broadcast their identity

- The mechanics of this are not complex but the interference potential to the network including new device to device co-existence issues needs to be thoroughly studied
- The target UE would need to be enabled with an uplink receiver which creates in-device co-existence issues with the UE transmitter
- Security and privacy aspects are also of significance

For D2D in the absence of a network there needs to be a complete rethink about synchronization

- The key enabling feature is the introduction of a relay UE which acts as a mobile base station

Low cost & enhanced coverage MTC UE for LTE

The Rel-11 “Study on Provision of low-cost MTC UEs based on LTE” concluded in TR 36.888 that it is possible to specify an LTE MTC device with a material cost comparable to that of an EGPRS

The Rel-12 work item “Low cost & enhanced coverage MTC UE for LTE” then defined a new UE category 0 which has lower requirements than UE category 1 from Rel-8. The main changes are:

- Single receiver (no MIMO or diversity reception)
- Baseband for data channels limited to 1.4 MHz (RF channels remain unchanged)
- Maximum transport block size limited to 1000 bits
- Half-duplex mode enabling use of a single oscillator is also being defined

Based on the Rel-11 “Study on RAN aspects of Machine Type and other mobile data applications Communications enhancements” documented in TR 37.869, the work item “RAN enhancements for Machine-Type and other mobile data applications Communications” was started which introduces a low power state in the non-access stratum (NAS) and signalling overhead reductions.

UE categories up to Release 12

UE Category	Downlink bitrate (Mbps)	Max # of spatial layers in DL	Uplink bitrate (Mbps)	Support for 64QAM in UL
0	1	1	1	No
1	10.296	1	5.160	No
2	51.024	2	25.456	No
3	102.048	2	51.024	No
4	150.752	2	51.024	No
5	299.552	4	75.376	Yes
6	301.504	2 or 4	51.024	No
7	301.504	2 or 4	102.048	No
8	2998.560	8	1497.760	Yes
9	452.256	2 or 4	51.024	No
10	452.256	2 or 4	102.048	No
11	603.008	2 or 4	51.024	No
12	603.008	2 or 4	102.048	No
13	391.632	2 or 4	51.024	No
14	391.632	2 or 4	102.048	No
15	3916.560	8	1497.760	Yes

Release 12
OTA , Positioning

OTA

- **Study of RF and EMC Requirements for Active Antenna Array System (AAS) Base Station**
- **Perf. part: Verification of radiated multi-antenna reception performance of UEs in LTE/UMTS**

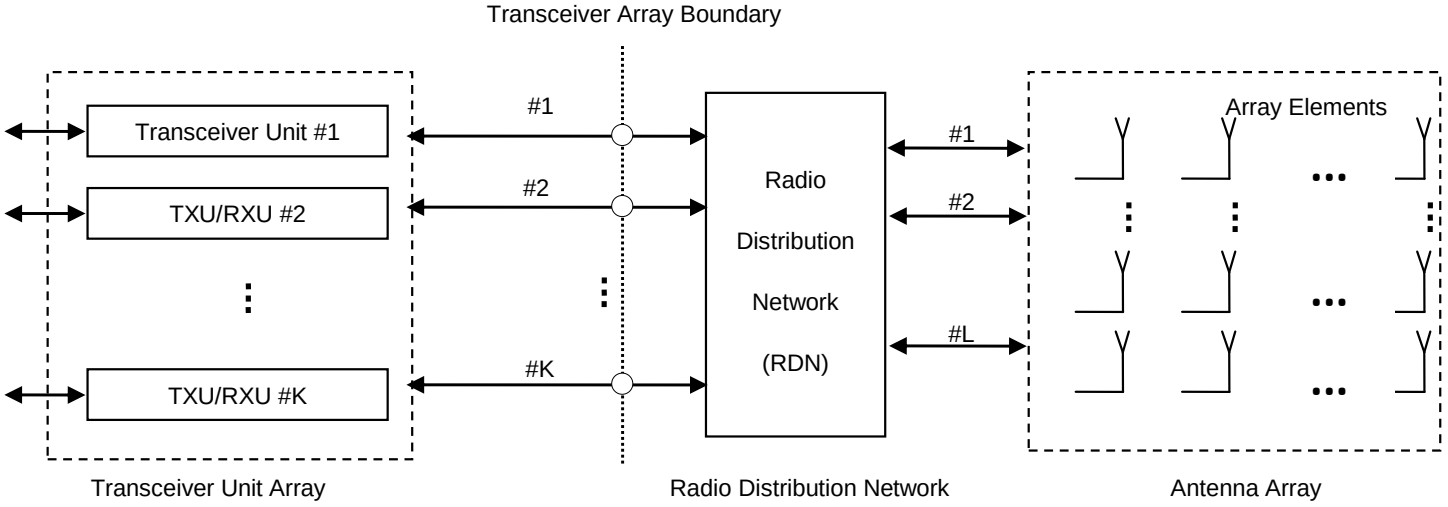
Positioning

- Study on Inclusion of RF Pattern Matching Technologies as a positioning method in the E-UTRAN
- Core part: Support for BeiDou Navigation Satellite System (BDS) for UTRA
- Core part: Support for BeiDou Navigation Satellite System (BDS) for LTE
- Core part: HNB Positioning for UTRA
- Core part: Positioning Enhancements for RF Pattern Matching in E-UTRA

Study of RF and EMC Requirements for Active Antenna Array System (AAS) Base Station

The exploitation of multiple antennas in base stations has been ongoing for years but has never been standardized

- This is changing since radio link assumptions of simple three-sectored cells no longer represents network reality
- The challenge is how to specify eNB performance in the spatial domain



General AAS Radio Architecture (TR 37.842 Figure 4.3-1)

Study of RF and EMC Requirements for Active Antenna Array System (AAS) Base Station

Like with other OTA work it has proved difficult to make progress

The Rel-12 work item “Base Station (BS) RF requirements for Active Antenna System” started in March 2013 has been moved to Release 13 for Dec 2015 completion.

Performance Requirements are expected by Jun 2016.

Verification of radiated multi-antenna reception performance of UEs: MIMO OTA

Work has been ongoing since Rel-9 in March 2009!

The initial study was turned into a work item concluding in Dec 2012 with TR 37.977 but no specifications as would normally be expected of a work item

Four test methods were approved in TR 37.977

- Multi-probe anechoic
- Two-stage
- Reverb
- Reverb + channel emulator

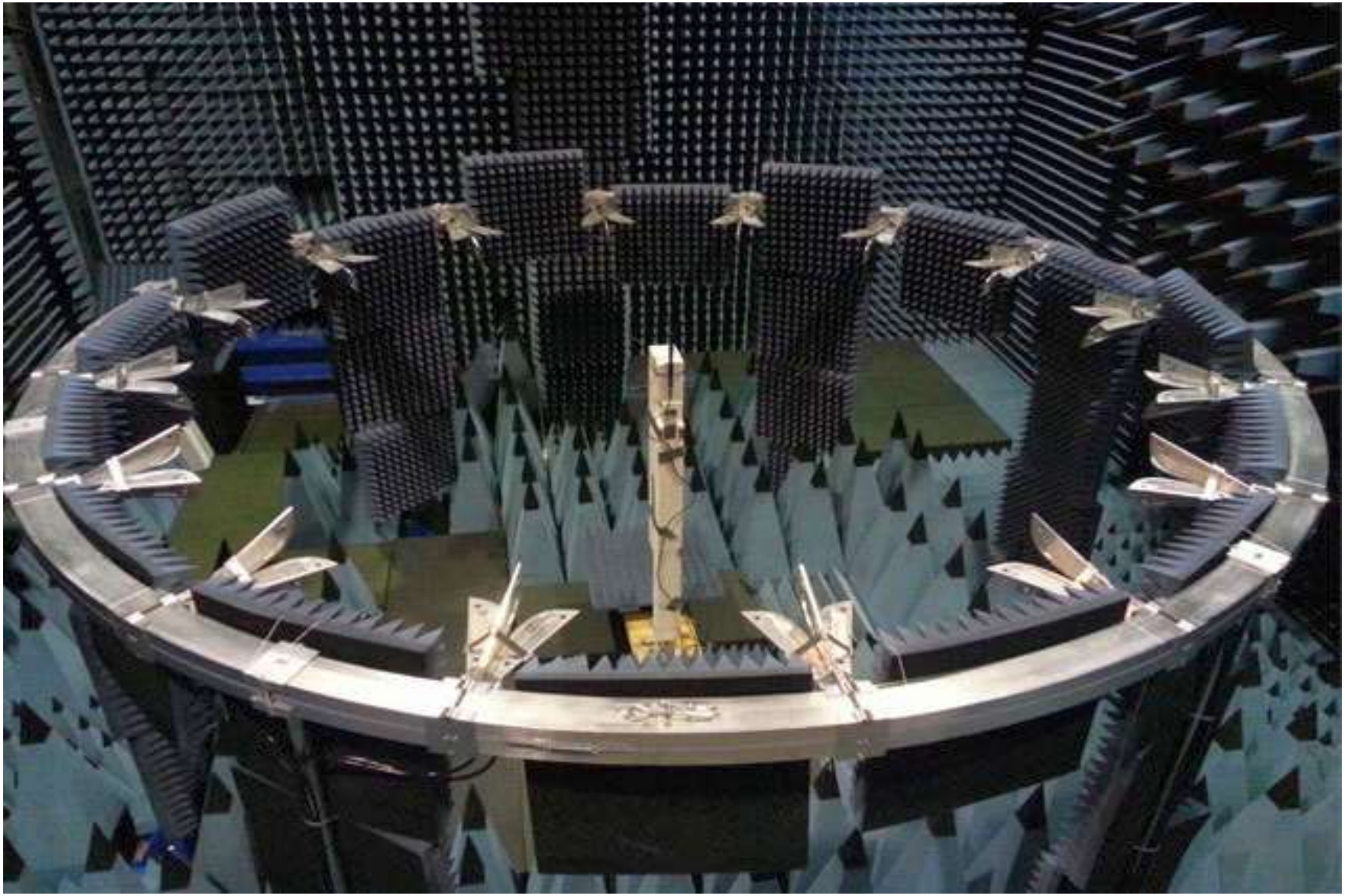
For more detail see www.keysight.com/find/LTEwebcasts

MIMO Over the Air (OTA) Handset Performance and Testing

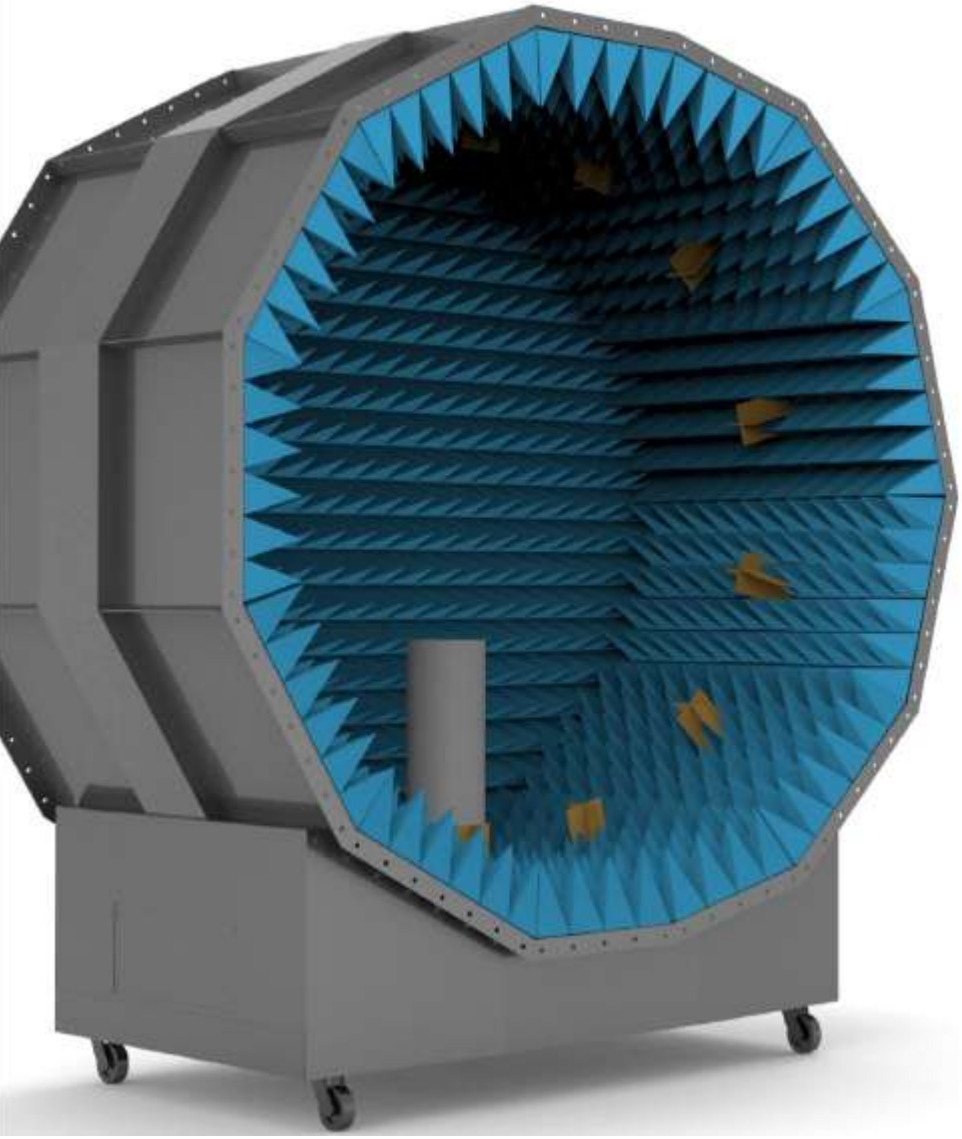
Comparison of MIMO OTA test methodologies

Method	Pros	Cons
Multi-probe anechoic	• Can handle dynamic antenna patters	• Highest cost • 3D extension very expensive • Cheaper options have limitations on device size (tablet or bigger)
Reverb Reverb with channel emulator	• Low cost • Inherently 3D	• Can't create realistic spatial channels or interference • Can't test polarized devices (e.g. laptops) • Not applicable to active antennas
Two-stage	• Low cost (can reuse SISO chamber) • Arbitrary 3D channels and interferers at no extra cost • No limits on device size	• UE test mode required • Not currently applicable to active antennas

16x2 Multi-probe anechoic chamber



GTS Rayzone 1800 Two-Stage test system



Release 12
Miscellaneous

- Study on Mobile Relay for E-UTRA
- Study on scalable UMTS FDD bandwidth
- Study on DCH Enhancements for UMTS
- Study on Energy Saving Enhancement for E-UTRAN
- Study on RAN Enhancements for UMTS/HSPA and LTE Interworking
- Study on RAN Aspects of RAN Sharing Enhancements for LTE
- Study on scalable UMTS FDD bandwidth by filtering
- Study on HNB Emergency Warning Area for UTRA
- Study and Core part: DCH Enhancements for UMTS
- Study and Core part: Enhanced Broadcast of System Information
- Study and Core part: New BS specification structure
- Study and Core part: Smart Congestion Mitigation in E-UTRAN
- Core part: HSPA signalling enhancements for more efficient resource usage for LCR TDD
- Core part: Public Warning System - Reset/Failure/Restart in Warning Message Delivery in LTE
- **Core part: LTE TDD-FDD joint operation including Carrier Aggregation**
- Core part: Further MBMS Operations Support for E-UTRAN
- Core part: Group Call eMBMS congestion management for LTE

LTE TDD-FDD joint operation including Carrier Aggregation

LTE supports both FDD and TDD duplex modes.

Handover mechanisms exist but not simultaneous operation (CA)

For operators with both FDD and TDD spectrum, it has become crucial to identify efficient mechanisms so that both spectrum resources can be fully utilized to improve system performance and user experience.

Either a TDD or FDD cell could be specified as the Pcell so a generic LTE FDD–TDD CA solution is needed

Other TDD–FDD joint operation solutions than CA may be identified based on the outcome of the initial phase of the work item, which is evaluating deployment scenarios and network/UE support requirements. 3GPP is using bands 8+40, 3+40, 1+41, and 1+42 as the example combinations

Release 13 RAN status

Due to the continued delays in finishing Rel-12, with further exceptions made till March 2015, only limited Release 13 work has been started.

As of Dec 2014 there were 148 Rel-13 work or study items:

- 133LTE, 7 UTRA, 8 LTE & UTRA

There are 36 items linked to new features

- 20 Study items for feasibility of new work
- 14 new features (non CA) 7 with corresponding performance requirements
- 2 performance-only requirements for features from earlier releases

The remaining 105 items are for CA and test

- 52 new CA combinations with corresponding performance requirements
- 1 conformance tests to date (conformance tests always lag new features)

Release 13 highlights – so far…

The following topics will be covered in more detail

- Spectrum - New frequency bands and carrier aggregation
- Licensed-Assisted Access using LTE
- Enhanced LTE Device to Device Proximity Services
- Further LTE Physical Layer Enhancements for MTC
- Elevation Beamforming/Full-Dimension (FD) MIMO for LTE
- MIMO OTA antenna test function for LTE
- LTE UE TRP and TRS and UTRA Hand Phantom related UE TRP and TRS Requirements
- Radiated requirements for the verification of multi-antenna reception performance of UEs

Classifying Rel-13 work and study items
37 work/study items (excluding CA)

There are again three significant categories

- **Spectrum** (7) –New bands and general carrier aggregation
- **Efficiency** (8) - Including interference management
- **Small cell / femto / HetNet** (4) – Includes WLAN and SON

Plus other topics that don't fit the above

- **D2D & MCC** (2) – Device to Device and Mission Critical Communications
- **MTC** (2) – Machine Type Communications
- **OTA** (6) – Radiated performance (antenna) aspects
- **Positioning** (2)

The remaining 6 cover a variety of miscellaneous smaller features

Release 13 Spectrum

- Study on LTE FDD in the bands 1980-2010 MHz and 2170-2200 MHz
- Core part: 2GHz FDD LTE Band for Region 1 (1980-2010MHz and 2170-2200MHz Bands)
- Study on Expansion of LTE_FDD_1670_US to include 1670-1680MHz Band for LTE in the US
- Study on Advanced Wireless Services (AWS)-Extension band for LTE
- Core part: LTE in the 1670-1675MHz Band for US

The above means between two and four new FDD bands

- FDD band numbering will restart as the original 32 have been used up

The other two items relate to carrier aggregation enhancements

- Core part: LTE Carrier Aggregation Enhancement Beyond 5 Carriers!
- Core part: HSPA Dual-Band UL carrier aggregation

Release 13
Efficiency

- Study on Downlink Enhancements for UMTS
- Study on Network-Assisted Interference Cancellation and Suppression for UMTS
- Study on Enhanced Multiuser Transmissions and Network Assisted Interference Cancellation for LTE
- Study on LTE DL 4 Rx antenna ports
- Core part: Enhanced Signalling for Inter-eNB Coordinated Multi-Point (CoMP) for LTE
- Core part: UE core requirements for uplink 64 QAM
- Perf. part: Performance requirements of MMSE-IRC receiver for LTE BS
- Perf. part: CRS Interference Mitigation for LTE Homogenous Deployments

Release 13
Small cell / femto / HetNet, D2D & MCC

Small cell / femto / HetNet

- Study on Multi-RAT Joint coordination
- **Study on Licensed-Assisted Access using LTE**
- Core part: SON for AAS-based deployments
- Study on Extension of Dual Connectivity in E-UTRAN
- Study on further enhancements of small cell higher layer aspects for LTE

D2D & MCC

- Study on Support of single-cell point-to-multipoint transmission in LTE
- **Core part: Enhanced LTE Device to Device Proximity Services**

Study on Licensed-Assisted Access using LTE (LAA)

Following considerable recent interest at 3GPP in the operation of LTE in unlicensed bands a new study item has been opened.

The previous name for this was LTE-Unlicensed (LTE-U), but LAA is likely to be the name moving forwards.

The purpose of LAA is to enable operators to offload traffic to LTE femtocells without having to implement WLAN

The initial focus is on the 5 GHz ISM band used for WLAN

Proposals are controversial since standard LTE interferes with WLAN

LTE is shown to be more efficient - but WLAN was there first

Modifications to the LTE air interface will be proposed to make co-existence with WLAN more tolerable (e.g. Listen Before Talk – LBT)

US regulations do not require LBT but Europe and Asia do

LAA is likely to become the single biggest increase of cellular spectrum (up to 680 MHz in 5 GHz band) since the allocations given at WRC 07 Then there is 60 GHz…

LAA Deployment scenarios (RWS-140029)

Initial results show that, when augmented with the appropriate coexistence mechanisms to operate in unlicensed spectrum, e.g. Listen-Before-Talk, LTE can effectively coexist with WiFi and outperform it in terms of spectral efficiency

<table>
<tr><th>Deployment model</th><th colspan="2">Mode of operation</th></tr>
<tr><td>Co-located cells</td><td rowspan="3">Licensed-Assisted</td><td rowspan="2">Carrier Aggregation</td></tr>
<tr><td>Non co-located cells w/ ideal backhaul</td></tr>
<tr><td>Non co-located cells w/out ideal backhaul</td><td>Dual Connectivity</td></tr>
<tr><td>Standalone cells</td><td colspan="2">Standalone</td></tr>
</table>

LAA Deployment scenarios (RWS-140029)

Strong interest to start first with **Licensed-Assisted Carrier Aggregation** operation leveraging on the existing LTE Carrier Aggregation framework

- Two available options:
  - (1) Cells on unlicensed spectrum used for downlink only
  - (2) Cells on unlicensed spectrum used for both downlink and uplink
- Many companies propose to start working on (1) then follow with (2)

Most of the companies see the value to study **Licensed-Assisted Dual Connectivity** operation as well, but prefer to do so at later time

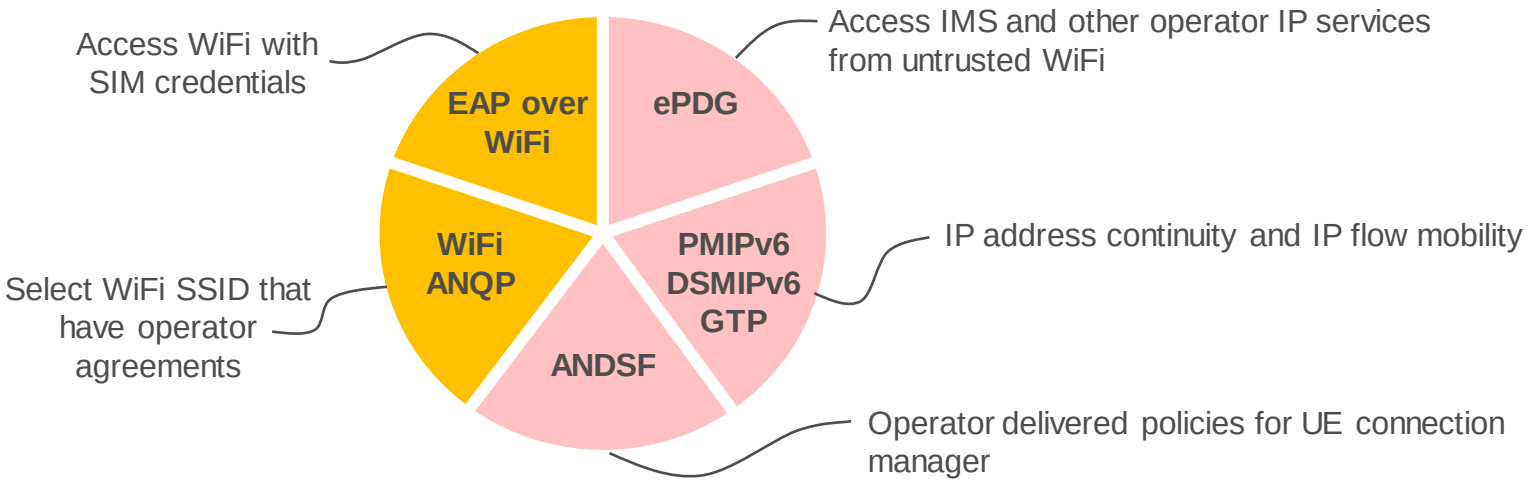
- The feature will hopefully leverage on the Dual Connectivity feature currently being developed in Rel-12

Diverging opinions on **Standalone** operation

- Some companies proposed to study also this mode; some companies explicitly requested not to study it.

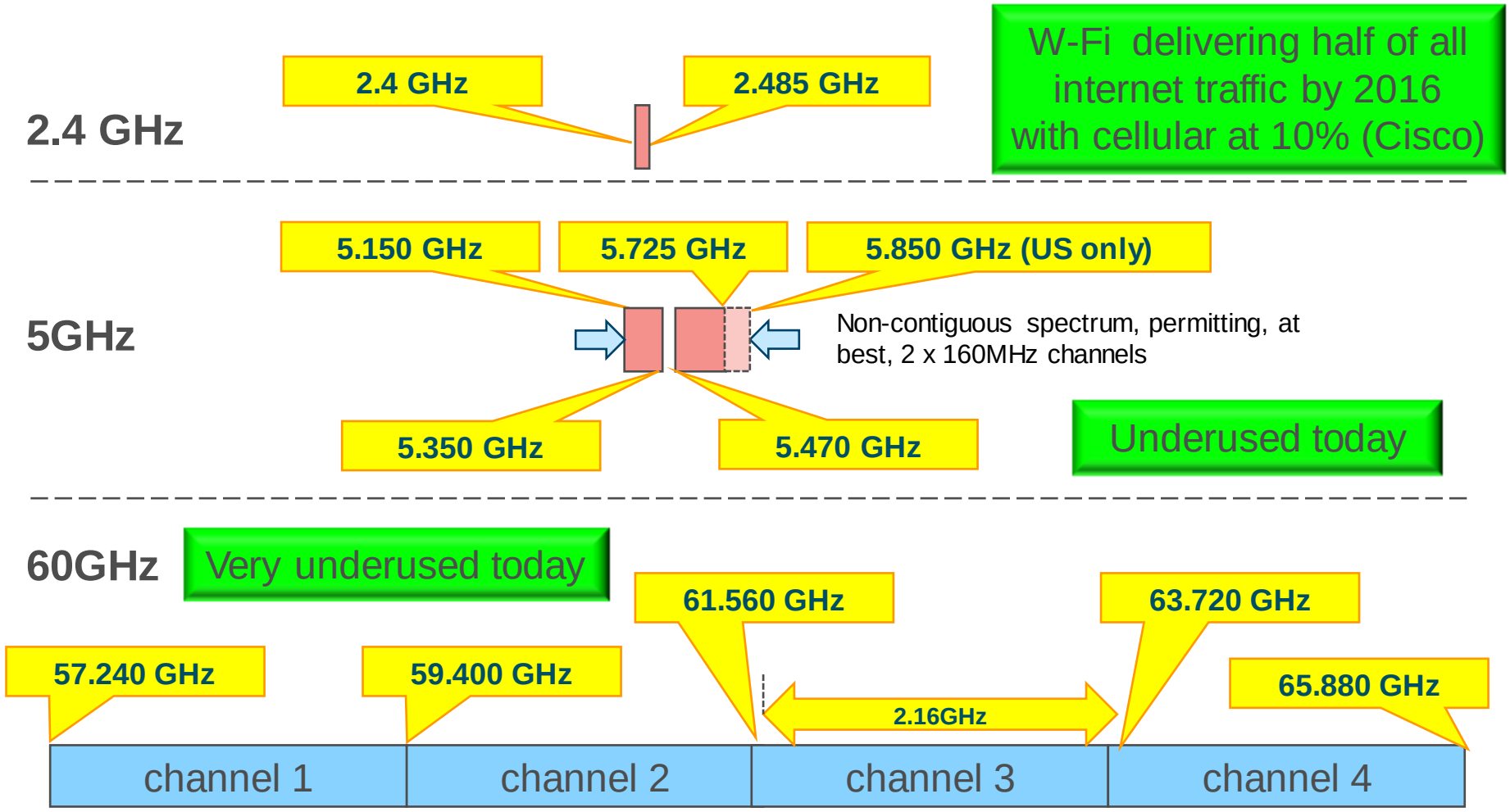
The alternative to LAA: Continued integration of cellular and Wi-Fi

802.11u/Hotspot 2.0 (Passpoint) **3GPP/I-WLAN**



EAP – Extensible Authentication Protocol
ANQP – Access network Query Protocol
ePDG – Evolved Packet Data Gateway
PMIPv6 – Proxy Mobil IP v6
DSMIPv6 – Dual Stack Mobility IP v6
GTP – GPRS Tunelling Protocol
ANDSF – Access network Discovery and Selection Function

Instrumentation Scientific Medical (ISM) spectrum



Enhanced device to device proximity services

Rel-12 specified:

- ProSe device to device discovery in network coverage.
- ProSe device to device broadcast communication.
- Higher layer (AS layer) support to enable groupcast and unicast over physical layer broadcast communication.

Rel-13 will further specify

- Enhanced in network coverage (intra-cell and inter-cell),
- Enhanced partial network coverage, and
- Enhanced outside network coverage scenarios
- Support the extension of network coverage using L3-based UE-to-Network Relays, including service continuity (if needed),
- Enhance D2D discovery support in the presence of multiple carriers and PLMNs:
- Consider mission critical push to talk (MCPTT) requirements

Release 13
MTC, OTA

MTC

- Study on small data transmission enhancement for UMTS
- **Core part: Further LTE Physical Layer Enhancements for MTC**

OTA

- **Study on Elevation Beamforming/Full-Dimension (FD) MIMO for LTE**
- **Study on MIMO OTA antenna test function for LTE**
- Core part: Base Station (BS) RF requirements for Active Antenna System (AAS) (was Rel-12)
- **Core part and conformance test aspects: LTE UE TRP and TRS and UTRA Hand Phantom related UE TRP and TRS Requirements**
- **Core part: Radiated requirements for the verification of multi-antenna reception performance of UEs**

Further LTE Physical Layer Enhancements for MTC

Based on the new Rel-12 category 0, Rel-13 will specify a low complexity UE category/type for MTC:

- Full or half duplex FDD or TDD mode:
- Reduced UE bandwidth of 1.4 MHz in downlink and uplink.
- Reduced maximum transmit power.
  - The maximum transmit power of the new UE power class should be determined by RAN4 and should support an integrated PA implementation.
- Reduced support for downlink transmission modes.
- Further relaxations can also be considered including:
  - Relaxed transmit and/or receive EVM requirement including restricted modulation scheme.
  - Reduced physical data channel processing (e.g. relaxed downlink HARQ time line or reduced number of HARQ processes).
  - Reduced support for CQI/CSI reporting modes.
- Coverage improvements of 15 dB
- Power consumption for ultra long battery life

Study on MIMO OTA antenna test function (ATF) for LTE

This work completes the definition fo the two-stage method started in 37.977.

The ATF defines two new UE measurements:

- RSAP – Reference Signal Antenna Power
  - The incident downlink power seen by the UE on each antenna
- RSARP – Reference Signal Antenna Relative Phase
  - The observed phase difference between the antennas

These two measurements are made by the UE on line-of-sight signals in an anechoic chamber. By rotating the device in 2D or 3D, the complex antenna pattern can be derived from which MIMO OTA throughput measurements can be made.

The adoption of TR 36.978 in Release 13 marks a major new development in the use of UE measurements for conformance testing.

This is made possible by calibrating the UE measurements using radiated test signals with known accuracy.

Study on Elevation Beamforming/Full-Dimension (FD) MIMO for LTE

The study will investigate in two phases the performance benefit of two-dimensional antenna array (up to 8 TXRU)

- Each TXRU has independent amplitude and phase control.

Phase 1:

- Identify antenna configurations and evaluation scenarios, and evaluate the performance of Rel-12 downlink MIMO using 3D channel model with realistic non-full buffer traffic model.

Phase 2:

- Study enhancements and assess the performance benefit of enhancements to the standard. Develop design principles for the identified techniques and identify potential specification impact.

LTE UE TRP and TRS and UTRA Hand Phantom related UE TRP and TRS Requirements

This work to define SISO radiated performance for devices including hand phantoms started back in December 2012

It has proven very difficult for the vendors and operators to reach agreement so the work has been moved to Release 13 with completion in Dec 2015

It took three years to set the original performance requirements for SISO TRP/TRS once the test method was final

It looks like it will take a similar time for SISO with and phantom

Radiated requirements for the verification of multi-antenna reception performance of UEs

The original work on MIMO OTA to define test methods was completed in Dec 2013

Since then the work has stopped due to the pressure to get Release 12 completed

A new work item was agreed in Dec 2014 to complete the work by harmonizing the different methods. specifying test system uncertainty and then UE performance requirements

Given that it has taken three years to set performance requirements for SISO it will be challenging to complete all this work by Dec 2015

It is possible that by the only the test method(s) will be complete

Release 13
Positioning, Miscellaneous

Positioning

- Study on Positioning enhancements for E-UTRA
- Study on Indoor Positioning Enhancements for UTRA and LTE

Miscellaneous

- Core part: RAN Aspects of RAN Sharing Enhancements for LTE
- Study on possible additional configuration for LTE TDD
- Study on RAN sharing enhancements for UMTS
- Study on performance enhancements for high speed scenario in LTE
- Core part: Support of EVS over UTRAN CS

Summary

The evolution of LTE since Release 8 shows no sign of slowing

Many of the most important innovations are recognizing the importance of **changing network topology** as a means of improving end user performance rather than the traditional focus on **spectral efficiency** and **peak channel bandwidth**

The key areas of cellular evolution likely to make the most difference to end users will be a combination of:

- Heterogeneous networks (integration of macro and small cells)
- Dual connectivity: Extension of carrier aggregation for inter-site
- Extension of dual connectivity to include Wi-Fi (controversial)
- The playing out of the LAA vs. traditional Wi-Fi offload without CA
- Radiated performance testing to include the quality of device and base station antennas which have largely been discounted, especially for MIMO

Reference materials

www.keysight.com/find/lte

www.keysight.com/find/lte-a-insight

www.keysight.com/find/lte-insight

www.keysight.com/find/LTEwebcasts

Useful 3GPP links and tools

List of Release 12 study and work items

List of Release 13 study and work items

Finding 3GPP specs

Finding 3GPP Temporary Documents (Tdocs)

Navigating RAN work/study items

Work item descriptions and status reports

Linking work and study items to changes in the specifications

Release 12 study items (1)

Name	Start	Finish	WID	Status
Study on Inclusion of RF Pattern Matching Technologies as a positioning method in the E-UTRAN	Dec.10	Sep.13	RP-120885	RP-131082
Study on Provision of low-cost MTC UEs based on LTE	Sep.11	June 13	RP-121441	RP-130583
Study on Mobile Relay for E-UTRA	Sep.11	June 14	RP-131375	RP-140726
Study of RF and EMC Requirements for Active Antenna Array System (AAS) Base Station	Sep.11	March 13	RP-111349	RP-130124
Study on LTE-HRPD (High Rate Packet Data in 3GPP2) inter RAT SON	March 12	June 13	RP-121982	RP-130585
Study on Passive InterModulation (PIM) handling for UTRA & LTE Base Stations	March 12	Sep.13	RP-120268	RP-131076
Study on Scenarios and Requirements of LTE Small Cell Enhancements	Sep.12	Dec.12	RP-121418	RP-121651
Study on UMTS Heterogeneous Networks	Sep.12	Dec.13	RP-121436	RP-131606
Study on CRS Interference Cancellation for Homogenous Deployments for LTE	March 13	Dec.13	RP-131840	RP-131623
Study on Network-Assisted Interference Cancellation and Suppression for LTE	March 13	March 14	RP-130404	RP-140472
Study on CoMP for LTE with Non-Ideal Backhaul	June 13	Dec.13	RP-130847	RP-131626
Study on HNB Emergency Warning Area for UTRA	June 13	March 14	RP-131258	RP-140129
Study on LTE Device to Device Proximity Services	Dec.12	March 14	RP-122009	RP-140416
Study on scalable UMTS FDD bandwidth	Dec.12	Dec.13	RP-130221	RP-132035
Study on DCH Enhancements for UMTS	Dec.12	Sep.13	RP-130216	RP-131073
Study on Small Cell Enhancements for E-UTRA and E-UTRAN – Physical-layer Aspects	Dec.12	Dec.13	RP-122032	RP-131618

Release 12 study items (2)

Name	Start	Finish	WID	Status
Study on 3D-channel model for Elevation Beamforming and FD-MIMO studies for LTE	Dec.12	Sep.14	RP-141237	RP-141206
Study on Further EUL Enhancements	Dec.12	Dec.13	RP-130347	RP-131608
Study on Small Cell Enhancements for E-UTRA and E-UTRAN – Higher-layer aspects	Dec.12	Dec.13	RP-122033	RP-131619
Study on WLAN/3GPP Radio Interworking	Dec.12	Dec.13	RP-122038	RP-131611
Study on Energy Saving Enhancement for E-UTRAN	Dec.12	June 14	RP-122035	RP-140604
Study on RAN Enhancements for UMTS/HSPA and LTE Interworking	Dec.12	Dec.13	RP-122036	RP-131612
Study on next-generation SON for UTRA and LTE	Dec.12	June 14	RP-122037	RP-140747
Study on 2GHz FDD for UTRA and LTE in Region 1 (1980-2010MHz and 2170-2200MHz Bands)	Dec.12	Sep.14	RP-140505	RP-141099
Study on Base Station specification structure	Dec.12	June 13	RP-122039	RP-130580
Study on RAN aspects of Machine Type & other mobile data applications Communications enhancements	March 13	Sep.13	RP-130396	RP-131081
Study on Enhanced Broadcast of System Information	Sep.13	Dec.13	RP-131386	RP-131610
Study on Group Communication for LTE	Sep.13	March 14	RP-131382	RP-140182
Study on Smart Congestion Mitigation in E-UTRAN	Sep.13	March 14	RP-132092	RP-140102
Study on RAN Aspects of RAN Sharing Enhancements for LTE	Dec.13	June 14	RP-132116	RP-140746
Study on scalable UMTS FDD bandwidth by filtering	Dec.13	June 14	RP-132122	RP-140988

Release 12 non-CA work items (1)

Name	Start	Finish	WID	Status
Core part: Carrier based HetNet ICIC for LTE	March 11	June 13	RP-121198	RP-130500
Core part: LTE in the US Wireless Communications Service (WCS) Band 30	Sep.12	June 13	RP-130843	RP-130569
Core part: Introduction of LTE 450 MHz band in Brazil	Sep.12	June 13	RP-121414	RP-130567
Core part: Further Downlink MIMO Enhancement for LTE-Advanced	Sep.12	June 14	RP-121416	RP-140652
Core part: Further enhancements for H(e)NB mobility-Part 3	Sep.12	Dec.13	RP-130741	RP-131508
Core part: New Carrier Type for LTE	Sep.12	Sep.13	RP-122028	RP-130984
Core part: Support for BeiDou Navigation Satellite System (BDS) for UTRA	March 13	Dec.13	RP-130416	RP-131500
Core part: RAN aspects for SIPTO at the Local Network	March 13	Dec.13	RP-130372	RP-131512
Core part: Support for BeiDou Navigation Satellite System (BDS) for LTE	March 13	Dec.13	RP-130416	RP-131525
Core part: E-UTRA Small cell enhancements - Physical layer aspects	Dec.13	Dec.14	RP-141459	RP-141899
Core part: Increasing the minimum number of carriers for UE monitoring in UTRA and E-UTRA	Dec.13	Dec.14	RP-132061	RP-141787
Core part: RAN enhancements for Machine-Type and other mobile data applications Communications	Dec.13	Sep.14	RP-140752	RP-141096
Core part: Inter-eNB CoMP for LTE	Dec.13	Dec.14	RP-140983	RP-141804
Core part: WLAN/3GPP Radio Interworking	Dec.13	Sep.14	RP-140981	RP-141310
Core part: Further EUL enhancements	Dec.13	Dec.14	RP-140127	RP-141860
Core part: UMTS Heterogeneous Networks enhancements	Dec.13	Sep.14	RP-141701	RP-141702
Core part: Enhanced Broadcast of System Information	Dec.13	Sep.14	RP-140131	RP-141230
Core part: Further Enhancements to LTE TDD for DL-UL Interference Management and Traffic Adaptation	Dec.12	June 14	RP-121772	RP-140724
Core part: HSPA signalling enhancements for more efficient resource usage for LCR TDD	Dec.12	Dec.13	RP-121984	RP-131499
Core part: Hetnet Mobility Enhancements for LTE	Dec.12	Sep.14	RP-122007	RP-141413
Core part: Further enhancements for HeNB mobility-X2-GW	Dec.12	June 14	RP-122006	RP-140592
Core part: Public Warning System - Reset/Failure/Restart in Warning Message Delivery in LTE	March 13	June 14	RP-130398	RP-140637
Core part: Low cost & enhanced coverage MTC UE for LTE	June 13	Dec.14	RP-140522	RP-142024
Core part: LTE TDD-FDD joint operation including Carrier Aggregation	June 13	June 14	RP-140465	RP-140982
Core part: LTE Coverage Enhancements	June 13	June 14	RP-130833	RP-140683

Release 12 non-CA work items (2)

Name	Start	Finish	WID	Status
Core part: HNB Positioning for UTRA	June 13	Dec.13	RP-132037	RP-131974
Core part: New BS specification structure	June 13	Dec.13	RP-130851	RP-131513
Core part: L-band for Supplemental Downlink in E-UTRA and UTRA	June 13	June 14	RP-140092	RP-140633
Core part: LTE-HRPD (High Rate Packet Data in 3GPP2) inter-RAT SON	June 13	June 14	RP-130831	RP-140745
Core part: Further MBMS Operations Support for E-UTRAN	Sep.13	Dec.14	RP-140282	RP-141821
Core part: DCH Enhancements for UMTS	Sep.13	Sep.14	RP-140771	RP-141137
Core part: UMTS Mobility enhancements for Heterogeneous Networks	Sep.13	June 14	RP-132039	RP-140636
Core part: Dual Connectivity for LTE	Dec.13	Dec.14	RP-141797	RP-141796
Core part: LTE Device to Device Proximity Services	March 14	March15	RP-142043	RP-141894
Core part: Smart Congestion Mitigation in E-UTRAN	March 14	Sep.14	RP-140434	RP-141292
Core part: Positioning Enhancements for RF Pattern Matching in E-UTRA	March 14	June 14	RP-140177	RP-140591
Core part: Network-Assisted Interference Cancellation and Suppression for LTE	March 14	Dec.14	RP-141634	RP-141866
Core part: Group Call eMBMS congestion management for LTE	June 14	March 15	RP-141035	RP-141863
Perf. part: Verification of radiated multi-antenna reception performance of UEs in LTE/UMTS	March 12	Dec.13	RP-120368	RP-131507
Perf. part: Performance Requirements of 8 Rx Antennas for LTE UL	Dec.12	Dec.13	RP-121709	RP-131523
Perf. part: Performance requirements of interference cancellation and suppression receiver for SU-MIMO	March 14	March 15	RP-140520	RP-141906
Perf. part: E-UTRA UE demodulation/Channel State Information (CSI) performance requirements for multiple Carrier Aggregation configurations	June 14	March 15	RP-141304	RP-141839

Release 13 study items

Name	Start	Finish	WID	Status
Study on LTE FDD in the bands 1980-2010 MHz and 2170-2200 MHz	Sep.12	March 15	RP-141154	RP-141851
Study on Expansion of LTE_FDD_1670_US to include 1670-1680MHz Band for LTE in the US	March 13	Dec.14	RP-130202	RP-141815
Study on Positioning enhancements for E-UTRA	June 13	Dec.14	RP-130680	RP-142224
Study on small data transmission enhancement for UMTS	Sep.14	June 15	RP-141861	RP-141859
Study on Downlink Enhancements for UMTS	Sep.14	June 15	RP-141901	RP-142233
Study on Elevation Beamforming/Full-Dimension (FD) MIMO for LTE	Sep.14	June 15	RP-141831	RP-141822
Study on Licensed-Assisted Access using LTE	Sep.14	June 15	RP-141817	RP-141816
Study on Multi-RAT Joint coordination	Dec.13	June 15	RP-132086	RP-141838
Study on Advanced Wireless Services (AWS)-Extension band for LTE	June 14	Dec.14	RP-141037	RP-141968
Study on MIMO OTA antenna test function for LTE	June 14	Dec.14	RP-141325	RP-142045
Study on Indoor Positioning Enhancements for UTRA and LTE	June 14	Sep.15	RP-141102	RP-141818
Study on possible additional configuration for LTE TDD	Dec.14	Sep.15	RP-142248	-
Study on Network-Assisted Interference Cancellation and Suppression for UMTS	Dec.14	Sep.15	RP-142250	-
Study on Enhanced Multiuser Transmissions and Network Assisted Interference Cancellation for LTE	Dec.14	Dec.15	RP-142315	-
Study on Support of single-cell point-to-multipoint transmission in LTE	Dec.14	June 15	RP-142205	-
Study on Extension of Dual Connectivity in E-UTRAN	Dec.14	March 15	RP-142257	-
Study on further enhancements of small cell higher layer aspects for LTE	Dec.14	Sep.15	RP-142283	-
Study on RAN sharing enhancements for UMTS	Dec.14	June 15	RP-142284	-
Study on LTE DL 4 Rx antenna ports	Dec.14	March 15	RP-142299	-
Study on performance enhancements for high speed scenario in LTE	Dec.14	Sep.15	RP-142307	-

Release 13 non-CA work items (1)

Name	Start	Finish	WID	Status
Core part: Base Station (BS) RF requirements for Active Antenna System (AAS)	March 13	Dec.15	RP-142235	RP-141908
Perf. part: Base Station (BS) RF requirements for Active Antenna System (AAS)	March 13	June 16	RP-142235	RP-141908
Core part: Further LTE Physical Layer Enhancements for MTC	Sep.14	Dec.15	RP-141865	RP-141785
Core part: SON for AAS-based deployments	Sep.14	June 15	RP-141624	RP-141854
Perf. part: Further LTE Physical Layer Enhancements for MTC	Sep.14	June 16	RP-141865	RP-141785
Core part: LTE in the 1670-1675MHz Band for US	March 12	Sep.14	RP-121397	RP-141452
Perf. part: LTE in the 1670-1675MHz Band for US	March 12	Sep.14	RP-121397	RP-141452
Core part: LTE UE TRP and TRS and UTRA Hand Phantom related UE TRP and TRS Requirements	Dec.12	Dec.15	RP-141966	RP-141973
UE Conformance Test Aspects - LTE UE TRP and TRS and UTRA Hand Phantom	March 14	June 15	RP-140090	RP-141848
Core part: Enhanced Signalling for Inter-eNB Coordinated Multi-Point (CoMP) for LTE	June 14	June 15	RP-141032	RP-141805
Core part: 2GHz FDD LTE Band for Region 1 (1980-2010MHz and 2170-2200MHz Bands)	June 14	June 15	RP-141710	RP-141795
Perf. part: 2GHz FDD LTE Band for Region 1 (1980-2010MHz and 2170-2200MHz Bands)	June 14	June 15	RP-141710	RP-141795
Core part: RAN Aspects of RAN Sharing Enhancements for LTE	Sep.14	Sep.15	RP-141671	RP-141891
Core part: Base Station (BS) RF requirements for Active Antenna System (AAS)	March 13	Dec.15	RP-142235	RP-141908
Perf. part: Base Station (BS) RF requirements for Active Antenna System (AAS)	March 13	June 16	RP-142235	RP-141908
Core part: Further LTE Physical Layer Enhancements for MTC	Sep.14	Dec.15	RP-141865	RP-141785
Core part: SON for AAS-based deployments	Sep.14	June 15	RP-141624	RP-141854
Perf. part: Further LTE Physical Layer Enhancements for MTC	Sep.14	June 16	RP-141865	RP-141785

Release 13 non-CA work items (2)

Name	Start	Finish	WID	Status
Core part: LTE Carrier Aggregation Enhancement Beyond 5 Carriers	Dec.14	Dec.15	RP-142286	-
Core part: Support of EVS over UTRAN CS	Dec.14	Sep.15	RP-142282	-
Core part: Enhanced LTE Device to Device Proximity Services	Dec.14	Dec.15	RP-142311	-
Core part: Radiated requirements for the verification of multi-antenna reception performance of UEs	Dec.14	Dec.15	RP-142221	-
Core part: UE core requirements for uplink 64 QAM	Dec.14	Sep.15	RP-142222	-
Core part: HSPA Dual-Band UL carrier aggregation	Dec.14	Dec.15	RP-142237	-
Perf. part: LTE Carrier Aggregation Enhancement Beyond 5 Carriers	Dec.14	June 16	RP-142286	-
Perf. part: Enhanced LTE Device to Device Proximity Services	Dec.14	June 16	RP-142311	-
Perf. part: Performance requirements of MMSE-IRC receiver for LTE BS	Dec.14	June 16	RP-142223	-
Perf. part: CRS Interference Mitigation for LTE Homogenous Deployments	Dec.14	June 15	RP-142263	-
Perf. part: HSPA Dual-Band UL carrier aggregation	Dec.14	March 16	RP-142237	-

Finding 3GPP specs
Things have changed

3GPP redesigned their website early in 2014

Previous links to specs were in the form:

ftp://ftp.3gpp.org/Specs/html-info/...

and are now found at

http://www.3gpp.org/ftp/specs/html-info/...

Which gets redirected to

http://www.3gpp.org/DynaReport/...

To find specifications start here:

http://www.3gpp.org/specifications/specification-numbering

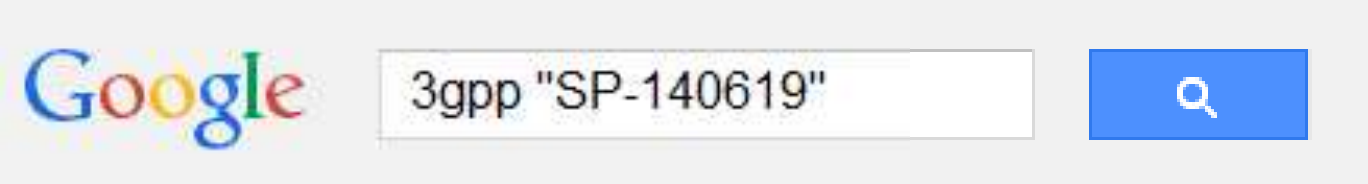
Finding 3GPP Temporary Documents (Tdocs)

As well as the public specifications and reports, all 3GPP temporary documents (Tdocs) can be found online.

Access to 3GPP Tdocs is through the working group meetings folders which can be found under ftp://ftp.3gpp.org/tsg_ran/ but you need to know committee and the meeting number.

However, a Google search will usually find any Tdoc in one click so try that first.

Put 3GPP in the search and quote the Tdoc number. E.g.



will return the ftp folder where the document can be found.

3GPP Document numbering

All 3GPP temporary documents (Tdocs) come in the form CC-YYXXXX where:

CC is the committee, YY is the year and XXXX is the Tdoc number

At the Technical Specifications Group plenary level, CC is given by:

- SA – System Aspects
- CP – Core Network and Terminals
- RP – Radio Access network
- GP – GERAN – GSM EDGE RAN

At the sub working group level CC is given by

- S1, S2, S3, S4, S5 – SA sub working groups
- C1, C2, C3 – CT sub working groups
- R1, R2, R3, R4, R5 – RAN sub working groups
- G1, G2, G3 – GERAN sub working groups

For a full list of what the TSGs and sub working groups are responsible for see:
http://www.3gpp.org/specifications-groups/specifications-groups

Navigating RAN work/study items

www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_66/Info_for_workplan/

TSG RAN has five working groups

- RAN WG1 – Physical layer
- RAN WG2 – Air interface signalling
- RAN WG3 – Core network signalling
- RAN WG4 – Radio aspects
- RAN WG5 – UE Conformance testing

RAN meet four times a year and the working groups meet between four and 8 times a year

One a quarter the RAN secretary produces a report which can be used as the starting point for any further investigation into the workings of the committees

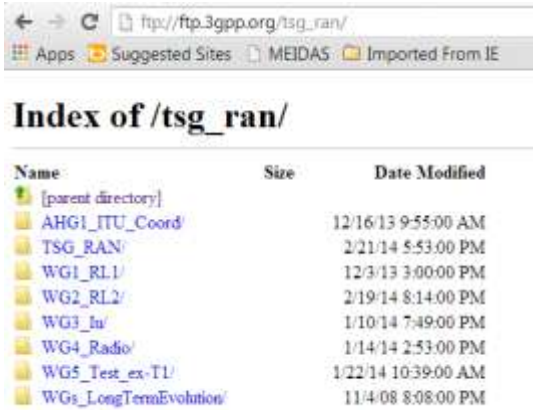
The committee working areas are public domain and can be found at

ftp.3gpp.org

Navigating RAN work/study items

At ftp.3gpp.org there is a list of folders. Select tsg_ran which takes you to ftp://ftp.3gpp.org/tsg_ran/

From here you can see the structure of the RAN groups

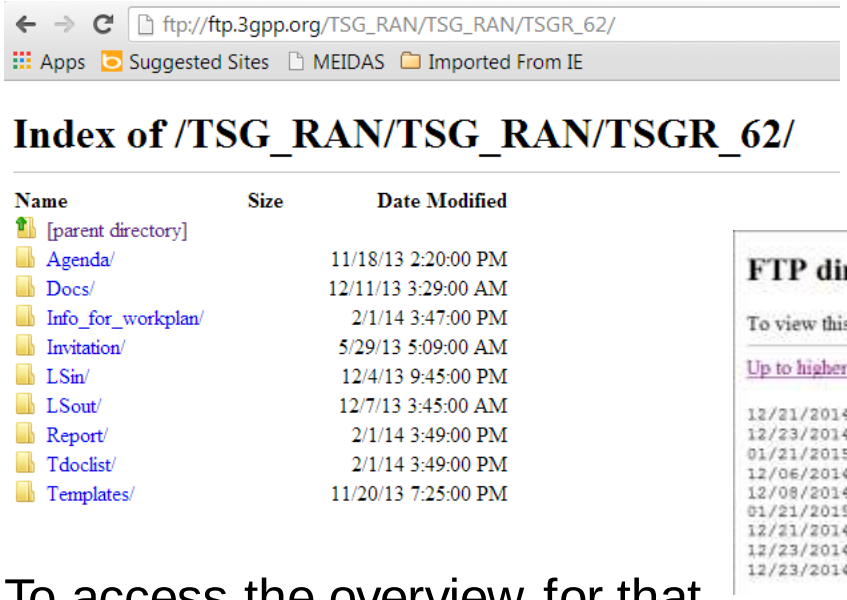


Select TSG_RAN to see the work of the RAN committee.

This will show a long list of folders called TSGR_XX. These are the quarterly RAN meetings. The list of upcoming meetings can be found at http://www.3gpp.org/3gpp-calendar.

Navigating RAN work/study items

Under each TSGR_XX folder is a standard structure. This is for meeting #62 (Dec 2013)



To access the overview for that meeting go into the Info for Workplan folder and download the latest overview.xlsx

Navigating RAN work/study items

Inside the overview spreadsheet is a list the 765 RAN work and study items going back to Release 7.

- For a complete picture, the 3GPP Workplan lists all the identifiable work packages that 3GPP has developed going back to Rel-99. There are currently 4591entries.

By careful sorting of this database a great deal of insight can be had about previous and ongoing work.

The column headings are described next

Overview spreadsheet column headings

UID	Unique ID (a number to identify the work package)
Acronym	A rather cryptic word to describe the work
C P T	Core, performance or Test
WI or SI	Indicates if a work item or a study item
Title	The verbal description of the work
REL	The expected release (can be changed if delays)
leading WG	Which working group has the lead
started	When the item started
finished or target	The expected finish data
level in %	Completion percentage
on hold until	In case the item is stalled
status	Closed, open, new etc.
latest WID/SID	The moss recent work or study item description document
latest status report	The most recent status report
F, BB, WT, SI	Feature, building block, work task or study item (procedural stuff)
rapporteur	The company leading the work
affected	UTRA (UMTS), LTE, MSR
spectrum related	Identifies spectrum-specific items
comments	As necessary
RAN #62 agenda item	Where to find it in the RAN plenary report

Further to the right are historical entries for previous RAN meetings finish date, completion %, status report. So from this single document the entire history of RAN work can be investigated.

Work Item Descriptions (WID)
Study Item Descriptions (SID)

Every piece of work starts with a WID or SID which has to be approved at RAN plenary before any work can be scheduled in the working groups.

A study item is just about feasibility and produces technical reports rather than technical specifications. Work items are the vehicle for writing specifications.

The SID is a single entity but the WID can consist of several parts, an overall feature, core building blocks and a performance part. This structure is being simplified from March 2014 onwards with a single WID document covering all elements.

Next we will look at an example.

Example WID

Let's say you want to find out about a particular piece of work. This might be located first by Release or searching for specific text.

Let's pick a Release 12 core WI for active antenna systems:

Title	REL	leading WG	started	finished or target	level in %	on hold until	status	latest WID/SID	latest status report	F, BB, WT, SI	rapporteur
Core part: Base Station (BS) RF requirements for Active Antenna System (AAS)	REL-12	R4	March 13	June 14	55		open	RP-130373	RP-131510	BB	Huawei

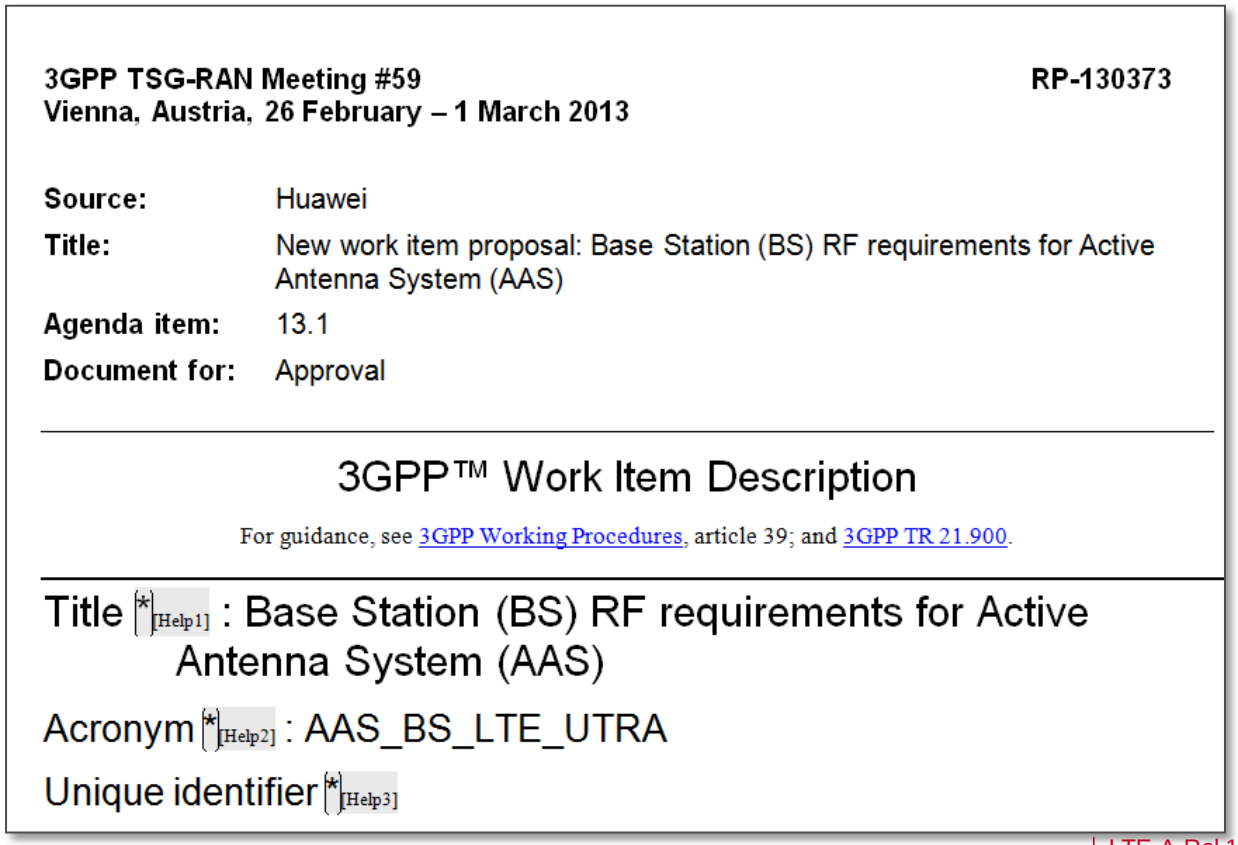
We can now look for the WID to understand the scope of the work in Tdoc RP-130373.

Unfortunately there are no hyperlinks to the RAN document but it can be found fairly easily. RP-130373 looks like the 2nd meeting of 2013 which was RAN #59.

Example WID

Navigating to the TSGR_59 we find:

ftp://ftp.3gpp.org/TSG_RAN/TSG_RAN/TSGR_59/Docs/RP-130373.zip



3GPP TSG-RAN Meeting #59 **RP-130373**
Vienna, Austria, 26 February – 1 March 2013

Source: Huawei

Title: New work item proposal: Base Station (BS) RF requirements for Active Antenna System (AAS)

Agenda item: 13.1

Document for: Approval

3GPP™ Work Item Description

For guidance, see 3GPP Working Procedures, article 39; and 3GPP TR 21.900.

Title *[Help1] : Base Station (BS) RF requirements for Active Antenna System (AAS)

Acronym *[Help2] : AAS_BS_LTE_UTRA

Unique identifier *[Help3]

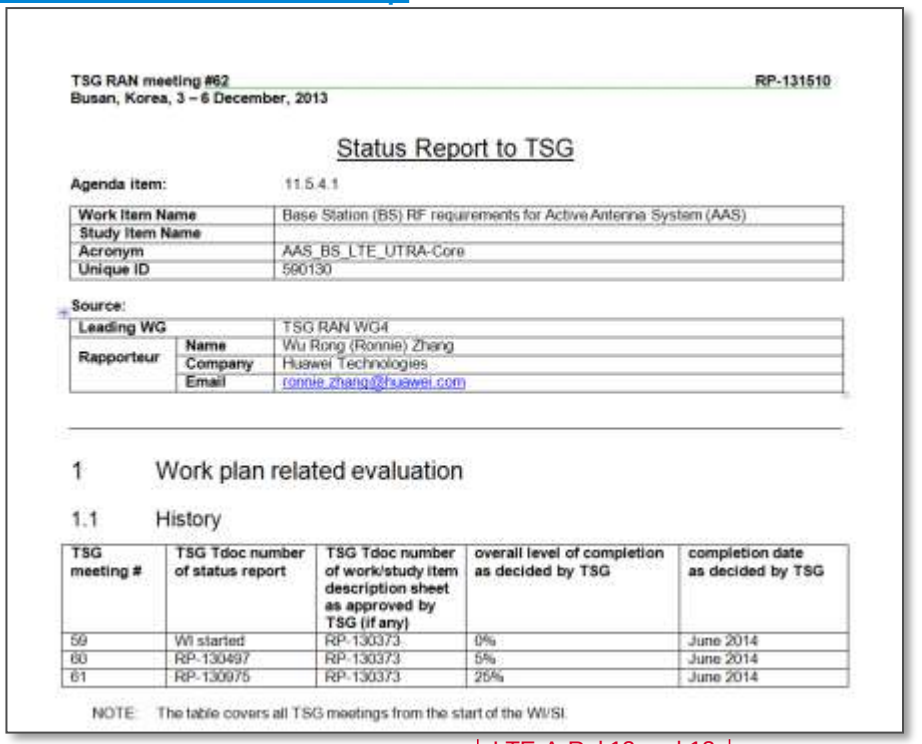
Example status report

Once understanding the scope of the work the next phase is to consult the latest status report which is produces one a quarter by the WI rapporteur. In this case the Tdoc is RP-131510 from meeting #62 which is found at:

ftp://ftp.3gpp.org/TSG_RAN/TSG_RAN/TSGR_62/Docs/RP-131510.zip

From the status report much more insight can be gained about the progress of the work and a list of the key WG Tdocs that were presented in the previous quarter.

No you are armed and dangerous!



TSG RAN meeting #62 RP-131510
Busan, Korea, 3 – 6 December, 2013

Status Report to TSG

Agenda item: 11.5.4.1

Work Item Name	Base Station (BS) RF requirements for Active Antenna System (AAS)
Study Item Name	
Acronym	AAS_BS_LTE_UTRA-Core
Unique ID	590130

Source:

Leading WG		TSG RAN WG4
Rapporteur	Name	Wu Rong (Ronnie) Zhang
	Company	Huawei Technologies
	Email	ronnie.zhang@huawei.com

1 Work plan related evaluation

1.1 History

TSG meeting #	TSG Tdoc number of status report	TSG Tdoc number of work/study item description sheet as approved by TSG (if any)	overall level of completion as decided by TSG	completion date as decided by TSG
59	WI started	RP-130373	0%	June 2014
60	RP-130497	RP-130373	5%	June 2014
61	RP-130975	RP-130373	25%	June 2014

NOTE: The table covers all TSG meetings from the start of the WI/SI

Linking work and study items to changes in the specifications

It is possible to find out exactly what specifications were affected by the work.

Go to http://www.3gpp.org/DynaReport/GanttChart-Level-2.htm

Select the Release of interest, find the Study or Feature of interest and expand using the "+" sign on the left to show the lower level items if necessary. Then click on the percentage completion to see a list of approved Change Requests associated with this work item.

Example work item impact on specifications Rel-12 – LTE_WCS_BAND

Expand all
(This may take several minutes)

Select release:
Rel-12

Select the desired release then search for the work item of interest.

Expand the WI to reveal the yellow lower level tasks and detail of impacted specifications

	570017	LTE_WCS_band	LTE in the US Wireless Communications Service (WCS) Band 30	85%	Rel-12		RP-130843	history	2013-06-11	RP#58 RP-121701 work can start based on FCC Order (FCC-12-130) http://hraunfoss.fcc.gov/edocs_public/attachmatch/FCC-12-130A1.pdf	LTE
	570117	LTE_WCS_band-Core	...Core part: LTE in the US Wireless Communications Service (WCS) Band 30	100%	Rel-12	R4;R2	RP-130843	history	2013-06-11	RP#60 completed. Updated WID RP-121419=>RP-130843	36.101, 36.104, 36.113, 36.124, 36.133, 36.307, 36.331, new TR 36.846
	570217	LTE_WCS_band-Perf	...Perf. Part: LTE in the US Wireless Communications Service (WCS) Band 30	100%	Rel-12	R4	RP-130843	history	2013-06-11	RP#60 completed. Updated WID RP-121419=>RP-130843	36.101, 36.133, 36.141
	640002	LTE_WCS_band-UEConTest	...Test Part: LTE in the US Wireless Communications Service (WCS) Band 30	40%	Rel-12	R5	RP-140643	history	2014-09-09	-	36.508, 36.521-1, 36.521-2, 36.521-3, 36.523-2, 36.523-3, 37.571-1

Example work item impact on specifications Rel-12 – LTE_WCS_BAND

By clicking on the percentage completion you get a list of al the approved change requests for that work item.

3GPP Work Item = 570117 (LTE_WCS_band-Core)

This page lists the approved Change Requests to 3GPP Technical Specifications and Reports associated with the above work item. Click on the CR find it in the CR table associated with the spec to which it pertains. Click on the spec to open its web page.

Spec	CR number and Revision	CR Title
25.101	0960	Introduction of Band 30
25.104	0653	Introduction of Band 30
25.104	0653 rev 1	Introduction of Band 30
25.123	0555	Introduction of Band 30
25.123	0555 rev 1	Introduction of Band 30
25.133	1279	Introduction of Band 30
25.133	1279 rev 1	Introduction of Band 30
25.461	0085	Introduction of Band 30

Clicking on a CR (e.g. 0960) takes you to the RAN and TSG Tdocs containing the change.

0960	-	B	Rel-12	11.5.0	12.0.0	Introduction of Band 30	RP-60	RP-130791	approved	R4	R4-67	R4-132258	agreed	2013-06-07	LTE_WCS_band-Core	-	2013-06-07