LTE Release 12 and Beyond

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Release of 3GPP specifications

1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014

Release 99 — **W-CDMA**

Release 4 — **1.28Mcps TDD**

Release 5 — **HSDPA**

Release 6 — **HSUPA, MBMS**

Release 7 — **HSPA+ (MIMO, HOM etc.)**

Release 8 — **LTE**

Release 9 — **Minor LTE enhancements**

Release 10 — **LTE-Advanced**

Release 11

Release 12 • • • • •

ITU-R M.1457
IMT-2000 Recommendation

ITU-R M.2012
IMT-Advanced Recommendation

To be frozen in June 2014

2

3GPP LTE Release 10 and 11

Key Features in Release 10

-))) Support of Wider Bandwidth(Carrier Aggregation)
  - Use of multiple component carriers(CC) to extend bandwidth up to 100 MHz
 - Common physical layer parameters between component carrier and LTE Rel-8 carrier

  ← Improvement of peak data rate, backward compatibility with LTE Rel-8
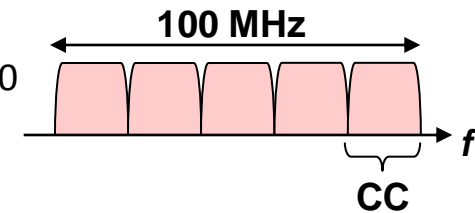
-))) Advanced MIMO techniques
  - Extension to up to 8-layer transmission in downlink
  - Introduction of single-user MIMO up to 4-layer transmission in uplink
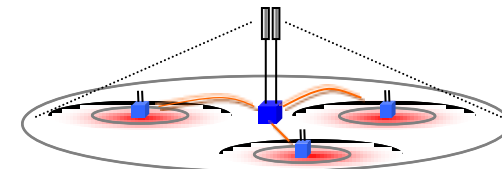 - Enhancements of multi-user MIMO

  ← Improvement of peak data rate and capacity
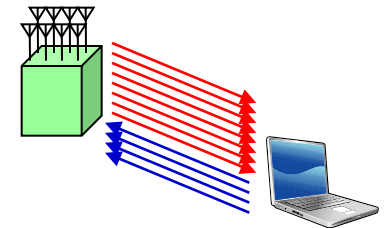
-))) Heterogeneous network and eICIC(enhanced Inter-Cell Interference Coordination)
  - Interference coordination for overlaid deployment of cells with different Tx power
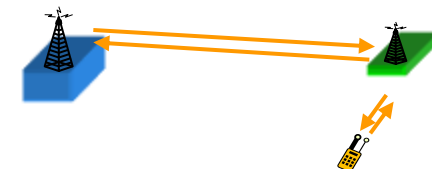
  ← Improvement of cell-edge throughput and coverage

-))) Relay
  - Type 1 relay supports radio backhaul and creates a separate cell and appear as Rel. 8 LTE eNB to Rel. 8 LTE UEs
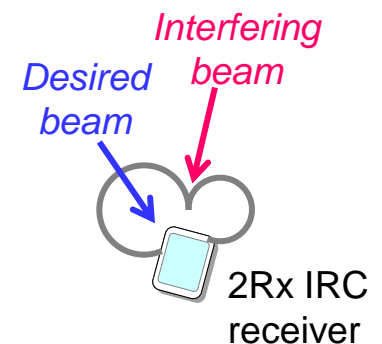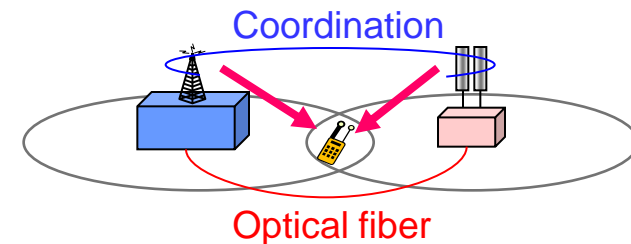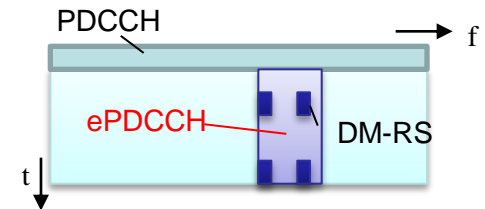
  ← Improvement of coverage and flexibility of service area extension

Key Features in Release 11 Physical layer aspects

- **Carrier aggregation (CA) enhancements**
  - Different TDD UL/DL configuration on different band
  - Multiple timing advances for UL CA
- **Enhanced downlink control channel (E-PDCCH)**
  - Enhanced DL control channel to support increased
  - control channel capacity, freq. domain ICIC, beamforming and/or diversity
- **CoMP transmission and reception**
  - CoMP for Homogeneous/Heterogeneous NW
    - Enhancement on DL/UL reference signal, control signal
    - Channel state information feedback and measurement
- **Further enhanced inter-cell interference coordination (FeICIC)**
  - Interference cancelation technique for UE (e.g., CRS canceller from Macro-cell)
- **Improved minimum performance requirements for E-UTRA: Interference rejection**
  - Interference rejection combining (IRC) UE receiver

PDCCH

f

ePDCCH

DM-RS

t

Coordination

Optical fiber

Interfering beam

Desired beam

2Rx IRC receiver

Key Features in Release 11
Higher layer aspects

- Enhancement of Minimization of Drive Tests (MDT)
  - Intention is to provide mechanisms to collect radio measurements together with location information from eNB/UE to reduce operator costs for performing manual drive tests
  - QoS measurements (e.g. throughput, traffic volume) added in Rel-11 specs
- RAN overload control for Machine-Type Communications (MTC)
  - Intention is to protect the NW from potentially very large number of MTC terminals
  - CN/RAN overload avoidance specific to MTC terminals added in Rel-11 specs
- Further self optimizing networks (SON) enhancements
  - Procedures for inter-RAT MRO added in Rel-11 specs
- Network Energy Saving
  - Procedures for inter-RAT energy saving added in Rel-11 specs
- LTE RAN Enhancements for Diverse Data Applications
  - Intention is to specify RAN improvements considering various data traffic, e.g. those generated by smartphones
  - Signaling for optimization of terminal battery consumption specified in Rel-11

3GPP LTE Release 12
(and Beyond?)

Release 12 Status Overview
(Physical Layer Aspects in June, 2013)

- Study Item
  - Small Cell Enhancement
  - 3D-channel model for Elevation Beamforming and Full Dimension-MIMO
  - Network-Assisted Interference Cancellation and Suppression
  - Device to Device (D2D) Proximity Services
    - Discovery/Communication
  - Enhanced Coordination Multi-Point (CoMP) Transmission/Reception
- Work Item
  - New Carrier Type (NCT)
    - Stand alone NCT/Non-stand alone NCT
  - Further enhancements to TDD for DL/UL Interference Management and Traffic Adaptation (eIMTA)
  - Further DL MIMO Enhancement
  - Low cost & enhanced coverage MTC UE
    - Low cost MTC
    - Coverage enhancement
  - TDD-FDD Carrier Aggregation
  - Coverage Enhancements

Small Cell Enhancements
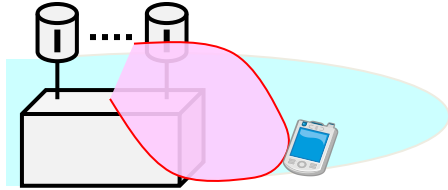## -PHY aspects-

📶 Objective

- Spectrum efficiency improvements
  - Higher order modulation (e.g., 256QAM)
  - Overhead reduction, control signaling enhancement
- Efficient small cell operation
  - Interference avoidance and coordination
  - Small cell ON/OFF, load balancing/shifting, et al.
  - Efficient small cell discovery
  - Radio Interface-based sync.
- Physical layer study for higher-layer aspects
  - Dual connectivity to macro and small cell layers
  - Mobility enhancements

📶 Study will be closed and specification works for identified technologies will start in Sep. 2013

RS

Replace RS by data

256QAM

Efficient discovery

Small cell OFF

Sync and/or coordination among small cells

Control functionalities

Realtime services (e.g., VoLTE)

Best effort services
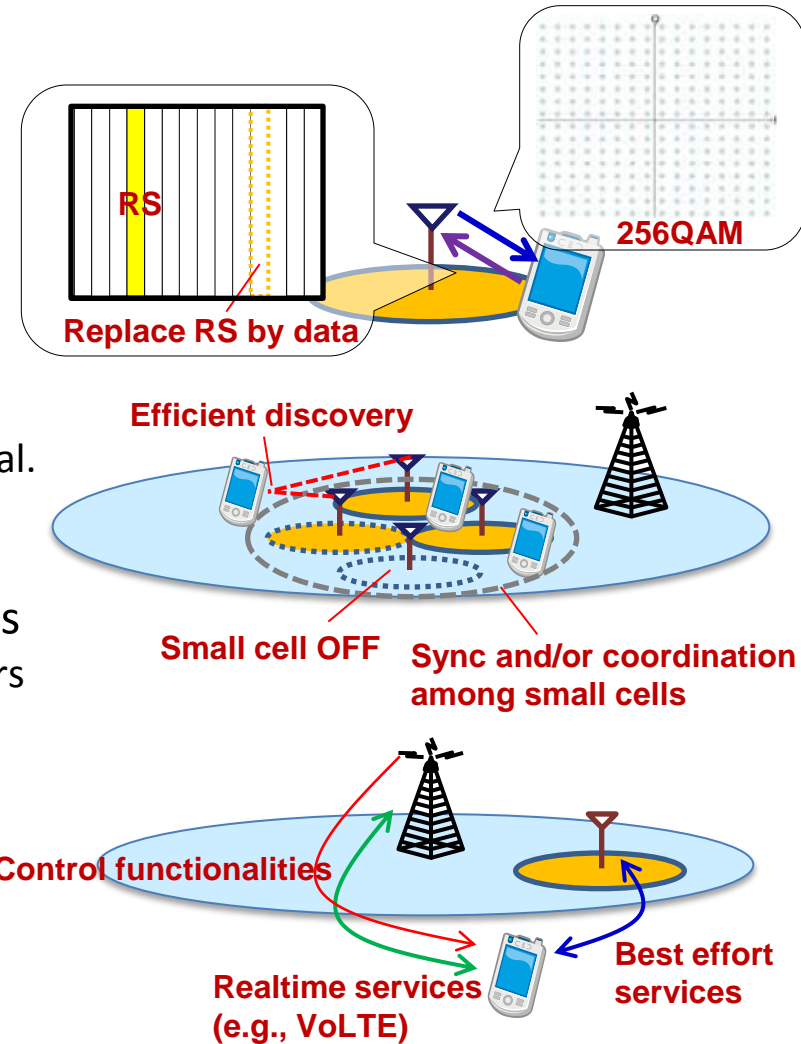
MIMO Enhancements

Rel-10 MIMO

- Max. 8-Tx (Max. 4-Tx for FDD)
- Achieves beamforming in azimuth angle

Optimization for realistic environment

Beamforming in azimuth/elevation angle

Enhancement of the number of antennas
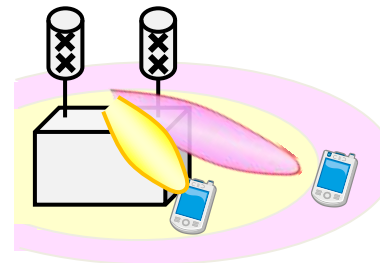
Rel-12 MIMO

2D MIMO enhancement
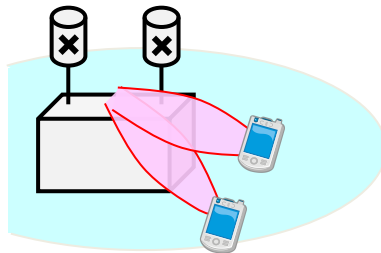
- 4-Tx codebook enhancement
- Feedback enhancement for MU-MIMO

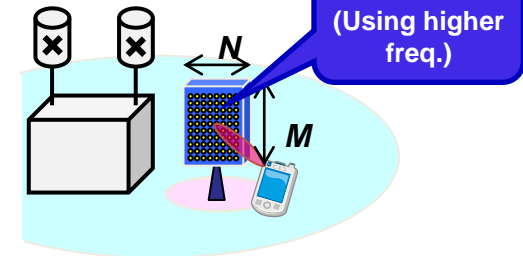### 3D MIMO using active antenna system

Study of 3D channel model (3D UE distribution, 3D pathloss, fast fading, etc

Elevation beam forming

Full dimension-MIMO

NxM antennas (Using higher freq.)

N

M

- Max. 8-Tx
➔ Beam gain and interference reduction using 3D beam

- More than 8-Tx (e.g., 16, 32, …)
- Higher freq. (e.g., 3.5 GHz-)
➔ Progressive capacity enhancement in hotspot area

NW-Assisted Interference Cancellation and Suppression

	Rel. 11 Advanced receiver	Rel. 12 Advanced receiver
Target for receiver	Interference limited areas, i.e., cell edge	All areas including cell edge

■**Target for Advanced receiver**

Inter-UE interference for MU-MIMO

Inter-cell interference at cell edge

Severer interference for other scenarios
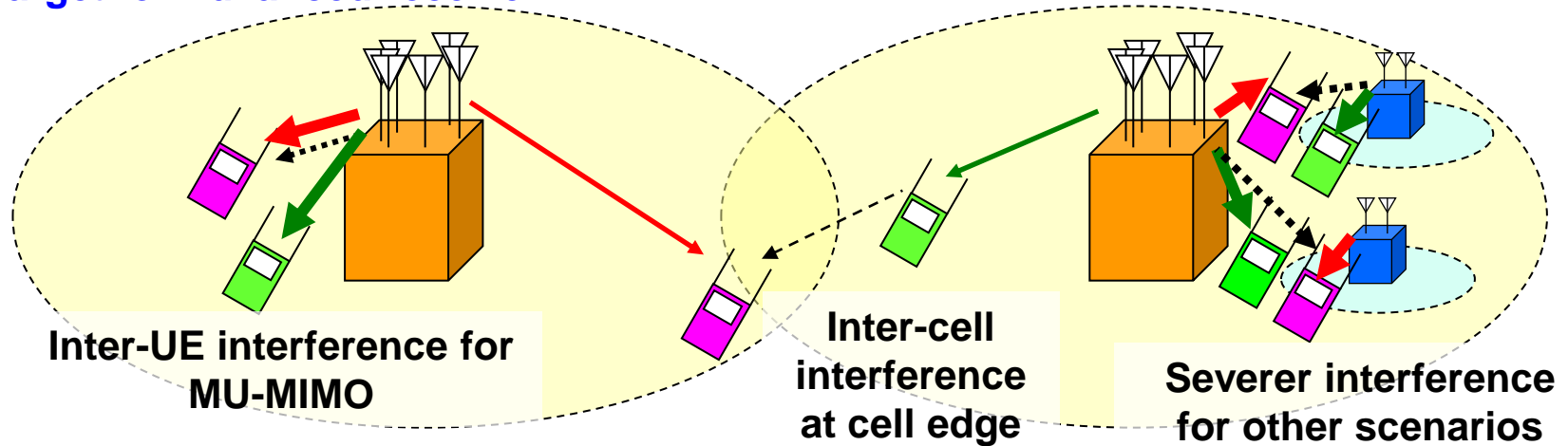
📶 Study on a variety of receiver types and need of interference information (NW-assisted receiver)

- Interference suppression: Enhancement of Rel-11 receiver
- Interference cancellation: Subtraction of interference replica from received signal, e.g., SIC

Device to Device (D2D) proximity service

- Two kinds of objective
  - Commercial use with NW coverage
  - Public safety/critical communication with/without NW coverage
- Two kinds of technical topics
  - D2D discovery
  - D2D communication

	With NW coverage	Without NW coverage
Discovery	Required both for public safety & non-public safety	Public safety only
Commu-nication	Required at least for public safety	Public safety only

12
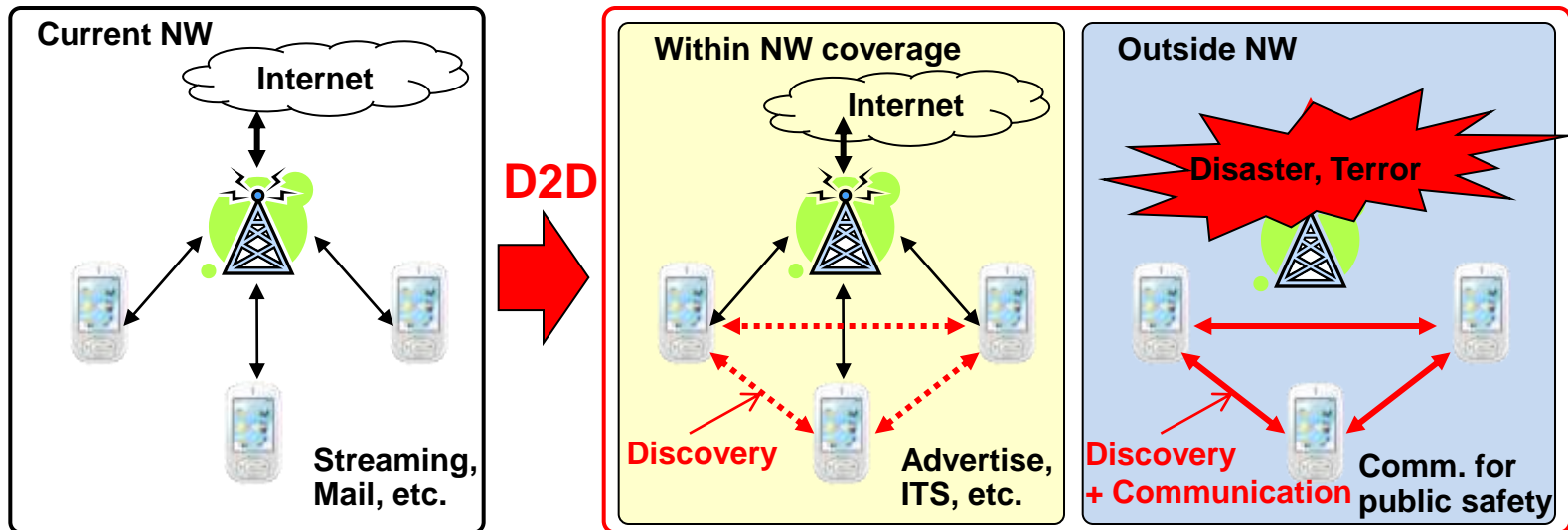
New Carrier Type (NCT)

- Objective
    - Improve system performance allowing Non-backward compatible carrier (Non-support for legacy LTE UE)
        - Less frequent transmission of cell-specific reference signal (CRS)
- Identified advantages
    - Enhanced spectrum efficiency by reducing overhead signal
    - Improved support for HetNet by avoiding interference from CRS
    - Energy efficiency by not transmitting DL signal
- Evaluating benefit of stand-alone NCT (support for idle mode UE)

Example of NCT scenario

LTE carrier   NCT

Higher frequency band
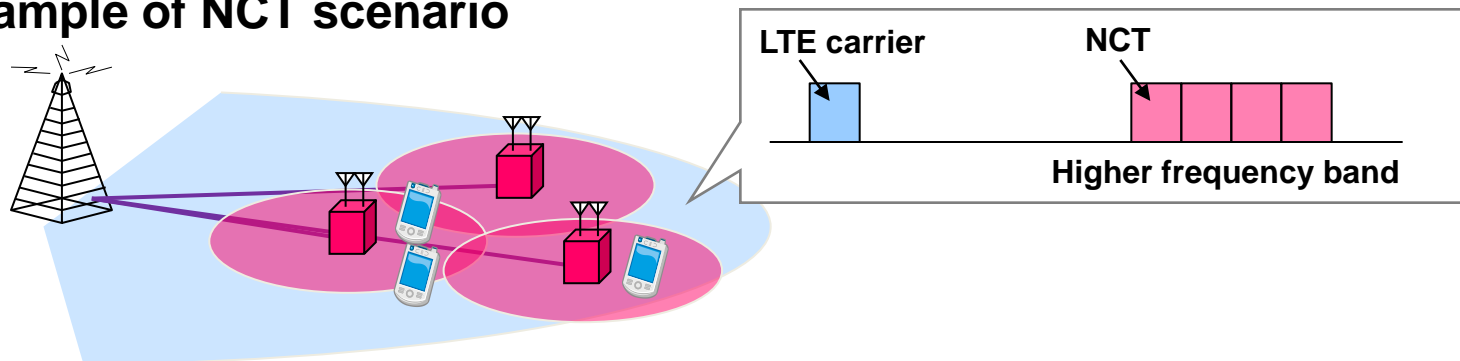
eIMTA* (Dynamic TDD)

* eIMTA: Further enhancements to LTE TDD for DL-UL interference management and traffic adaptation

Objective

- TDD UL-DL reconfiguration for traffic adaptation
- Interference mitigation with TDD UL-DL reconfiguration

Topics under discussion

- Reconfiguration mechanism
- Interference mitigation scheme

DL-to-UL interference

Cell 1

Cell 2

UL-to-DL interference
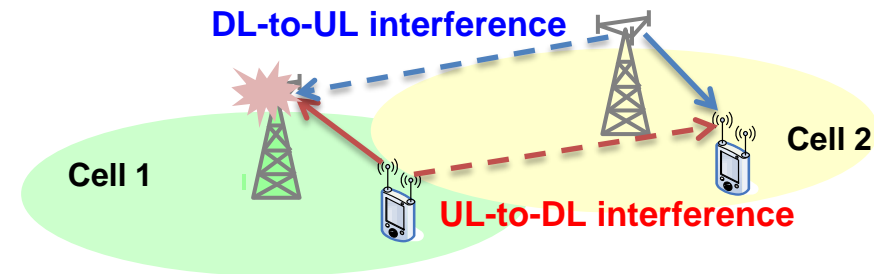
✓ **Interference mitigation schemes**

Scheme 1	Scheme 2
Cell clustering	**Scheduling enhancement**
Scheme 3	Scheme 4
Interference mitigation based on (F)eICIC	**Interference suppressing and mitigation**

LTE Operating Bands

FDD

Band	Frequency(UL/DL)(MHz)	Remark
1	1920-1980/2110-2170	IMT Core band (EU, Africa, Asia, etc.)
2	1850-1910/1930-1990	PCS1900 band (US, Canada, Americas)
3	1710-1785/1805-1880	GSM1800 band (EU, Africa, Asia, etc.)
4	1710-1755/2110-2155	AWS-1 (US, Canada, Americas)
5	824-849/869-894	GSM850 band (US, Canada, Americas, Asia, etc.)
6	830-840/875-885	Not applicable
7	2500-2570/2620-2690	IMT extension band (EU, Africa, Asia, etc.)
8	880-915/925-960	GSM900 band (EU, Africa, etc.)
9	1749.9-1784.9/1844.9-1879.9	Japan
10	1710-1770/2110-2170	Expanded Band 4
11	1427.9-1447.9/ 1475.9-1495.9	Japan
12	699-716/729-746	700 Lower in US
13	777-787/746-756	700 Upper C in US
14	788-798/758-768	700 Upper D in US
17	704-716/734-746	700 Lower in US
18	815-830/860-875	Japan
19	830-845/875-890	Japan
20	832-862/791-821	EU Digital Dividend
21	1447.9-1462.9/1495.9-1510.9	Japan
22	3410-3490/3510-3590	EU 3.5GHz band
23	2000-2020/2180-2200	US S-band
24	1626.5-1660.5/1525-1559	US L-band
25	1850-1915/1930-1995	Expanded Band 2
26	814-849/859-894	E850 Upper band
27	807-824/852-869	E850 Lower band
28	703-748/858-803	APT700
29	NA/716-728	US DL only
30	2305-2315 / 2350-2360	US LTE WCS
31	451-458 / 461-468	Brazil LTE 450

TDD

Band #	Frequency(MHz)	Remark
33	1900-1920	3G core band
34	2010-2025	3G core band
35	1850-1910	PCS1900 uplink band
36	1930-1990	PCS1900 downlink band
37	1910-1930	PCS Center Gap
38	2570-2620	3G extension band (EU, Africa, Asia, etc)
39	1880-1920	TD-SCDMA band in China
40	2300-2400	To be deployed in China
41	2496-2690	US 2.6 GHz band
42	3400-3600	EU 3.5GHz band
43	3600-3800	EU 3.5GHz band
44	698-806	APT 700

LTE Carrier Aggregation RF Requirements

2 DL and 1 UL

Inter-band

Band Comb.	Band Comb.
1+5	10+5/10(set 2)
3+7	4+5
4+13	4+7
4+17	5+17
7+20	8+20
5+12	11+18
4+12	2+29
2+17	4+29
3+5	1+8
10+5/10(set 1)	2+13
3+20	3+19
1+21	3+26
1+19	3+28
1+18	19+21
3+8	23+29

Intra-band contiguous

Band
1 (set 1)
40
41
1 (set 2)

Intra-band non-contiguous

Band
3
4
25
7

Many Work Items are on going and to be specified

2 DL and 2 UL

On going for 5 classes

A1. **Low-high band combination without harmonic relation between bands or intermodulation problem**

A2. **Low-high band combination with harmonic relation between bands**

A3. **Low-low or high-high band combination without intermodulation problem (low order IM)**

A4. **Low-low, low-high or high-high band combination with intermodulation problem (low order IM)**

A5. **Combination except for A1 – A4**

3 DL and 1 UL

Work Items have been started from June 2013

Thank you!

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More
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