Spectrum Management for 4G-LTE

Spectrum Management for 4G-LTE

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Consideration on Future Frequency Planning

01

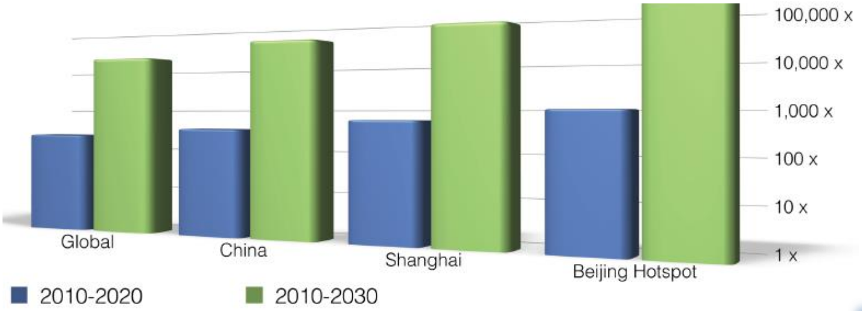
Global Frequency Planning for IMT

Global Frequency Planning for IMT

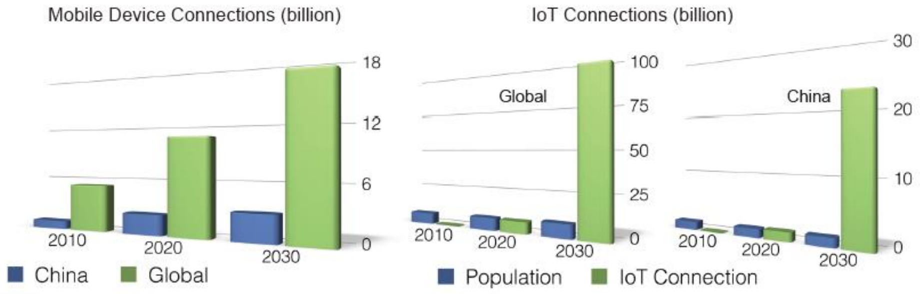
Spectrum is lifeblood of mobile communication system.

- The connecting devices of future global mobile networks will reach **100 billion**
- 2010-2020 the global mobile data traffic will grow by over **200 times** , and 2010-2030 by nearly **20,000 times** .
- In China, the growth is projected to be even higher, with 2010-2020 growth by over **300 times** and 2010-2030 by over **40,000 times**.

Growth of mobile data traffic



Growth of Mobile Device and IoT Connection



Traffic

- **Expansion of new resources**
- **Optimization of management**

Spectrum resource

Spectrum efficiency

bit/s/Hz

- **New technologies**
  - ✓ Large scale antenna arrays
  - ✓ Innovative multi-access techniques
  - ✓ Ultra-dense networking
  - ✓ ……

Estimated Spectrum Requirement

Spectrum Requirement (MHz)*		
Spectrum for	year 2015	year 2020
Final(China)	570-690	1490-1810
Final(Global result)	-	1340-1960MHz

- 700-1100MHz additional spectrum will be needed by 2020.
- Estimate for further beyond 2020 will consider more than just a sum but respective requirements in different scenarios.

Introduction of IMT

- International Mobile Telecommunications:

  International Telecommunication Union (ITU) develops the framework of standards for IMT, encompassing IMT-2000 and IMT-Advanced, spans the 3G and 4G industry perspectives and will continue to evolve as 5G with IMT-2020

Global 4G-LTE

LTE Market Status

717 operators investing in LTE in 190 countries
- 691 operator commitments in 185 countries
- 26 pre-commitment trials in 5 more countries

494 commercially launched LTE or LTE-Advanced networks in 162 countries

incl. 72 LTE TDD (TD-LTE) launched in 43 countries

GSA forecasts 550 commercially launched LTE networks by end 2016

5,104 LTE user devices announced
(GSA – April 7, 2016)

1.068 billion LTE subscriptions globally: Q4 2015

© GSA www.gsacom.com

226 operators (45.8%) commercially launched LTE networks in 104 countries use 1800 MHz

126 operators in 60 countries investing in VoLTE deployments, studies or trials

55 operators commercially launched VoLTE-HD voice in 34 countries

LTE-Advanced is a key industry trend

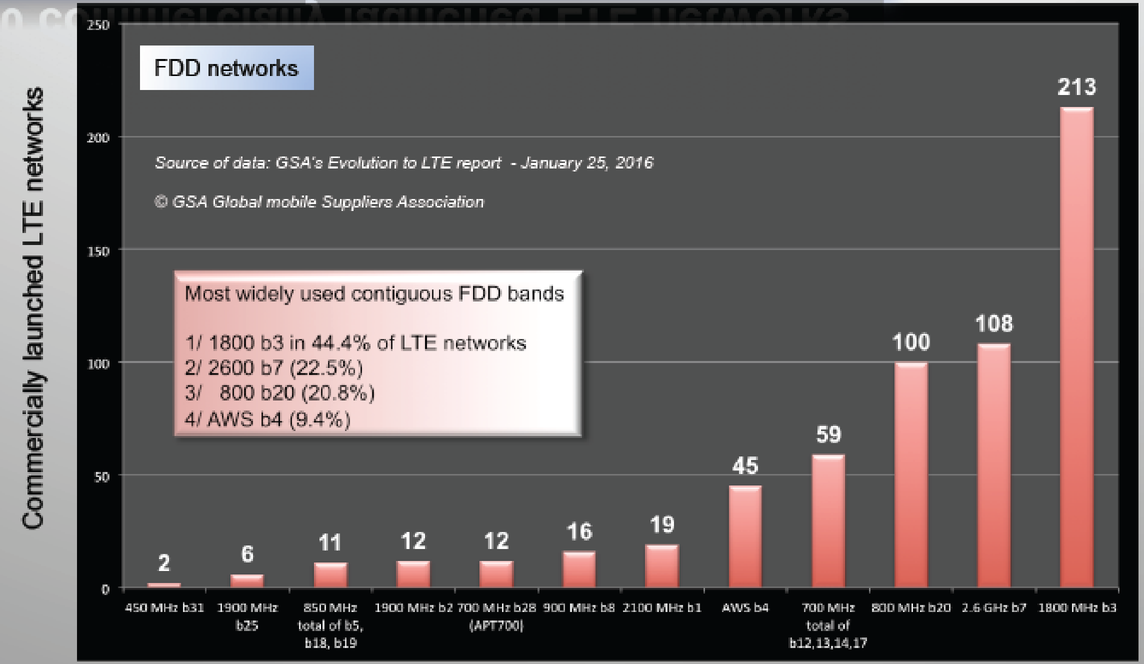
175 LTE operators are investing in LTE-Advanced deployments, studies or trials in 76 countries

127 commercially launched LTE-A networks in 61 countries

Global 4G-LTE Bands

Spectrum used currently in 480 commercially launched LTE networks

GSA
www.gsacom.com



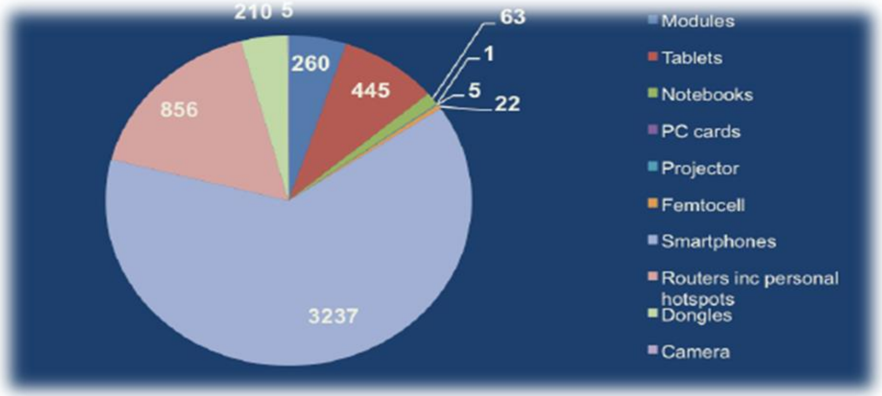
409 operators launched FDD mode only
50 operators launched TDD mode only
21 operators launched FDD &TDD modes
-----
480 commercially launched LTE networks

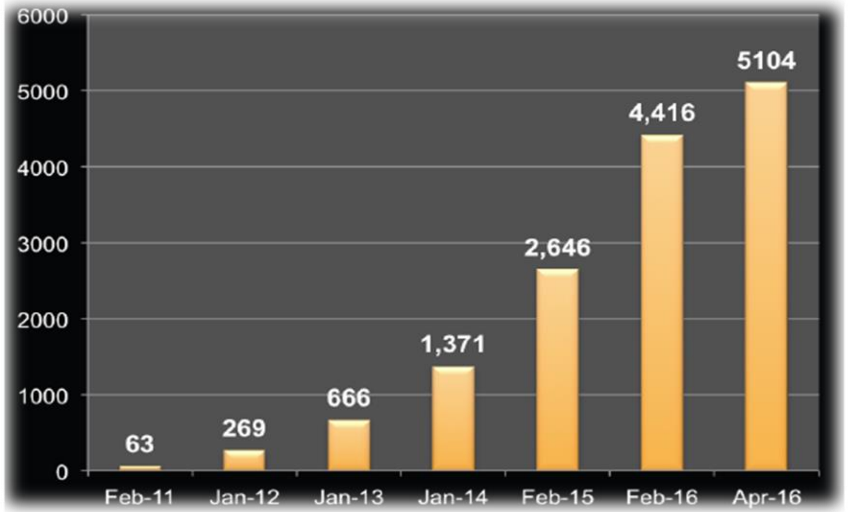
TDD networks

Band	No. of networks
38	16
39	1
40	28
41	15
42/43	17

Note: Some LTE TDD network deployments use more than one band

4G-LTE User Devices





LTE TDD	
2300 MHz band 40	1,435 devices
2600 MHz band 38	1,207 devices
2600 MHz band 41	1,121 devices
1900 MHz band 39	996 devices
3500 MHz band 42/43	64 devices

LTE FDD	
1800 MHz band 3	2,847 devices
2600 MHz band 7	2,638 devices
2100 MHz band 1	2,324 devices
800 MHz band 20	1,573 devices
800/1800/2600 tri-band	1,477 devices
AWS band 4	1,231 devices
850 MHz band 5	1,163 devices
900 MHz band 8	1,136 devices
700 MHz band 17	1,018 devices
1900 MHz band 2	1,031 devices
700 MHz band 13	575 devices
APT700 band 28	329 devices
1900 MHz band 25	257 devices
700 MHz band 12	248 devices

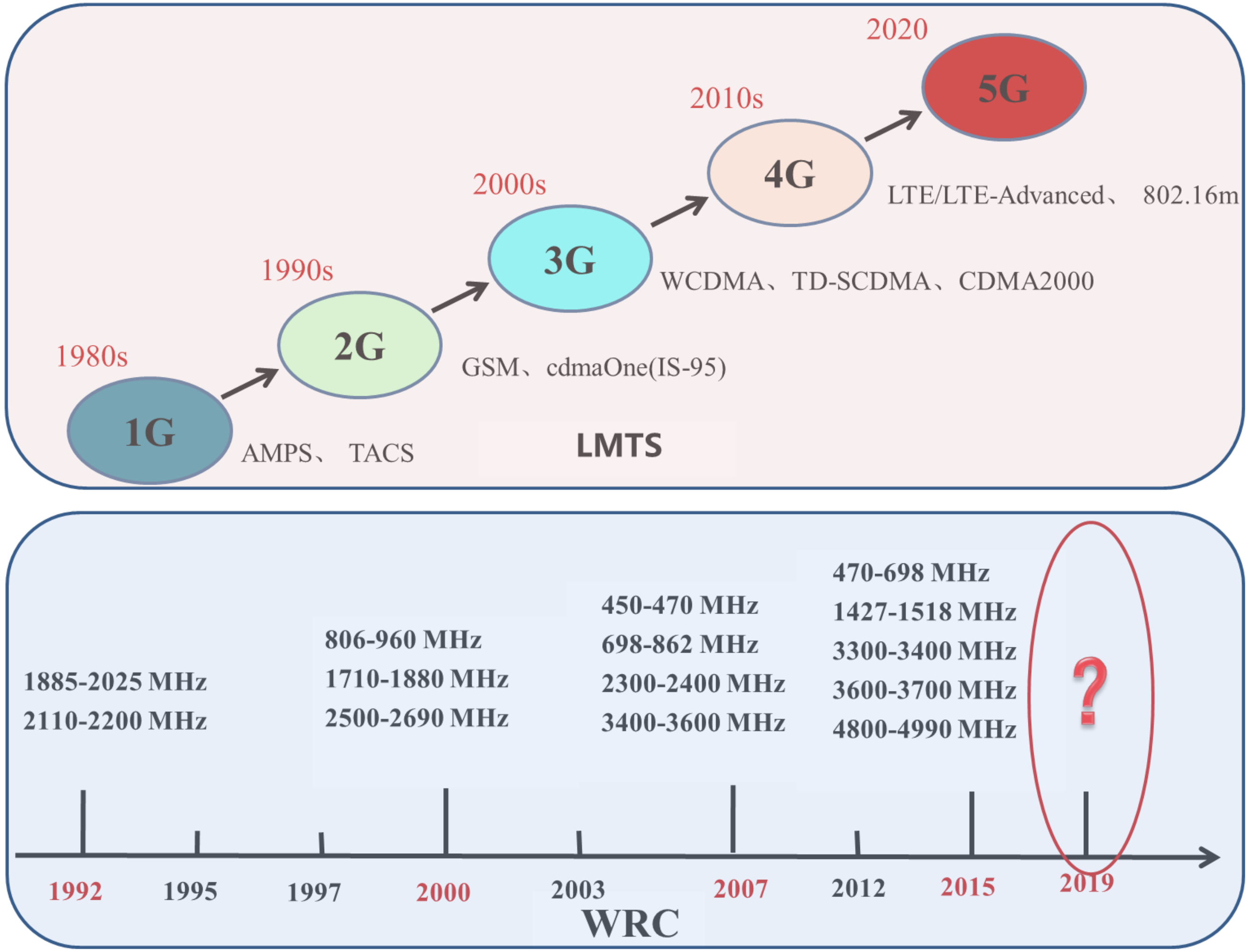
ITU Spectrum Management

- ITU coordinates the world's satellites through the management of spectrum and orbits, bringing you television, vehicle GPS navigation, maritime and aeronautical communications, weather information and online maps, and enabling communications in even the remotest parts of the planet.

3GPP Spectrum

- The project covers cellular telecommunications network technologies, including radio access, the core transport network, and service capabilities - including work on codecs, security, quality of service - and thus provides complete system specifications , especially definition of bands, RF specification.

Development of Mobile Communication



ITU Radio Regulation

- RR regulates on law of nations scale radiocommunication services and the utilization of radio frequencies.
- Revised regarding the World Radio Conference outputs every 3 to 4 years.

How to Identify IMT Spectrum in ITU

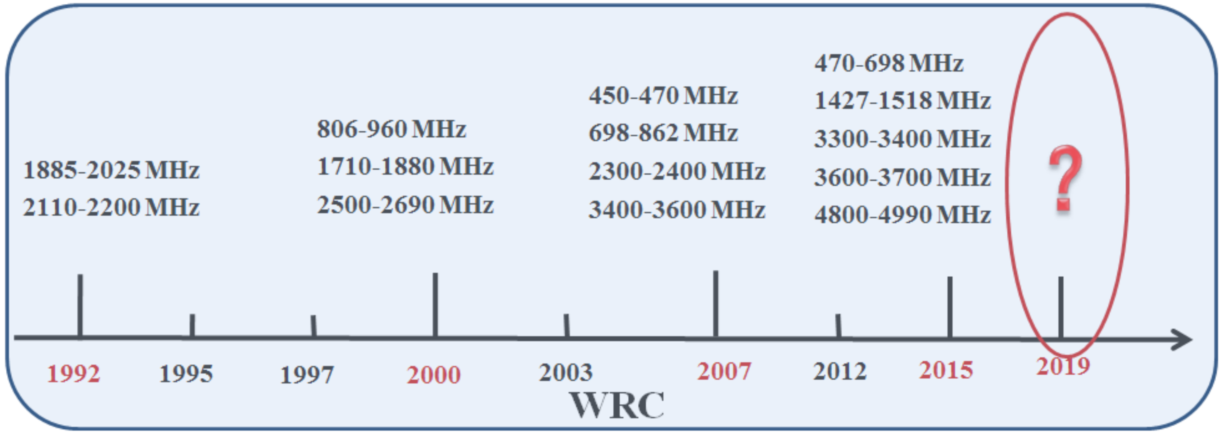
- Allocation for Mobile services
- Identify for IMT based on services

Allocation to services		
Region 1	**Region 2**	**Region 3**
450-455	FIXED MOBILE 5.286AA 5.209 5.271 5.286 5.286A 5.286B 5.286C 5.286D 5.286E	
455-456 FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	**455-456** FIXED MOBILE 5.286AA MOBILE-SATELLITE (Earth-to-space) 5.209 5.286A 5.286B 5.286C	**455-456** FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E
456-459	FIXED MOBILE 5.286AA 5.271 5.287 5.288	
459-460 FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E	**459-460** FIXED MOBILE 5.286AA MOBILE-SATELLITE (Earth-to-space) 5.209 5.286A 5.286B 5.286C	**459-460** FIXED MOBILE 5.286AA 5.209 5.271 5.286A 5.286B 5.286C 5.286E

5.286AA The band 450-470 MHz is identified for use by administrations wishing to implement International Mobile Telecommunications (IMT). See Resolution **224 (Rev.WRC-07)***. This identification does not preclude the use of this band by any application of the services to which it is allocated and does not establish priority in the Radio Regulations. (WRC-07)

IMT Global Frequency Planning

- IMT frequency bands utilization is globalized
- Frequency bands are identified for IMT at WRCs
- Frequency arrangements for IMT is detailed in the Rec ITU-R M.1036



ITU-R M.1036 Footnotes

Band (MHz)	Footnotes identifying the band for IMT
450-470	5.286AA
698-960	5.313A, 5.317A
1 710-2 025	5.384A, 5.388
2 110-2 200	5.388
2 300-2 400	5.384A
2 500-2 690	5.384A
3 400-3 600	5.430A, 5.432A, 5.432B, 5.433A

Administrations may deploy IMT systems in bands allocated to the mobile service other than those identified in the RR, and administrations may deploy IMT systems only in some or parts of the bands identified for IMT in the RR.

450-470MHz

Frequency arrangements in the band 450-470 MHz

Frequency arrangements	Paired arrangements				Un-paired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
D1	450.000-454.800	5.2	460.000-464.800	10	None
D2	451.325-455.725	5.6	461.325-465.725	10	None
D3	452.000-456.475	5.525	462.000-466.475	10	None
D4	452.500-457.475	5.025	462.500-467.475	10	None
D5	453.000-457.500	5.5	463.000-467.500	10	None
D6	455.250-459.975	5.275	465.250-469.975	10	None
D7	450.000-457.500	5.0	462.500-470.000	12.5	None
D8					450-470 TDD
D9	450.000-455.000	10.0	465.000-470.000	15	457.500-462.500 TDD
D10	451.000-458.000	3.0	461.000-468.000	10	None
D11 450.500-457.500	3.0	460.500-467.500	10		None

694-960MHz

Paired Frequency arrangements in the band 694-960 MHz

Frequency arrangements	Paired arrangements				Un-paired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
A1	824-849	20	869-894	45	None
A2	880-915	10	925-960	45	None
A3	832-862	11	791-821	41	None
A4	698-716 776-793	12 13	728-746 746-763	30 30	716-728
A5	703-748	10	758-803	55	None
A6	None	None	None		698-806
A7	703-733	25	758-788	55	None
A8	698-703	50	753-758	55	None
A9	733-736	52	788-791	55	None
A10	External	–	738-758	–	None
A11 (harmonized with A7 and A10)	703-733 External	25 –	758-788 738-758	55 –	None

Global Frequency Planning for IMT

1710-2200MHz

Frequency arrangements in the band 1710-2200 MHz

Frequency arrangements	Paired arrangements				Un-paired arrangements (e.g. for TDD) (MHz)	Relevant Notes
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)		
B1	1 920-1 980	130	2 110-2 170	190	1 880-1 920; 2 010-2 025	1, 2, 4
B2	1 710-1 785	20	1 805-1 880	95	None	1
B3	1 850-1 920	10	1 930-2 000	80	1 920-1 930	1, 2, 5
B4 (harmonized with B1 and B2)	1 710-1 785 1 920-1 980	20 130	1 805-1 880 2 110-2 170	95 190	1 880-1 920; 2 010-2 025	1, 2, 4
B5 (harmonized with B3 and partially harmonized with the downlink of B1 and the uplink of B2)	1 850-1 920 1 710-1 780	10 330	1 930-2 000 2 110-2 180	80 400	1 920-1 930	1, 2, 3, 5
B6	1 980-2 010	160	2 170-2 200	190	None	4, 5
B7	2 000-2 020	160	2 180-2 200	180	None	5

2300-2400MHz

Frequency arrangements in the band 2300-2400 MHz

Frequency arrangement	Paired arrangements				Un-paired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
E1					2 300-2 400 TDD

2500-2690MHz

Frequency arrangements in the band 2500-2690 MHz (not including the satellite component)

Frequency arrangements	Paired arrangements					Un-paired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	Centre gap usage	
C1	2 500-2 570	50	2 620-2 690	120	TDD	2 570-2 620 TDD
C2	2 500-2 570	50	2 620-2 690	120	FDD	2 570-2 620 FDD DL external
C3	Flexible FDD/TDD					

3400-3600MHz

Frequency arrangements in the band 3 400-3 600 MHz

Frequency arrangements	Paired arrangements				Un-paired arrangements (e.g. for TDD) (MHz)
	Mobile station transmitter (MHz)	Centre gap (MHz)	Base station transmitter (MHz)	Duplex separation (MHz)	
F1					3 400-3 600
F2	3 410-3 490	20	3 510-3 590	100	None

Global Frequency Planning for IMT

3GPP Bands

(TDD Bands)

Operating Band	Uplink (UL) operating band BS receive UE transmit FUL_low - FUL_high (MHz)	Downlink (DL) operating band BS transmit UE receive FUL_low - FUL_high (MHz)
33	1900–1920	1900–1920
34	2010–2025	2010–2025
35	1850–1910	1850–1910
36	1930–1990	1930–1990
37	1910–1930	1910–1930
38	2570–2620	2570–2620
39	1880–1920	1880–1920
40	2300–2400	2300–2400
41	2496-2690	2496-2690
42	3400–3600	3400–3600
43	3600–3800	3600–3800
44	703–803	703–803
45	1447–1467	1447–1467
46	5150– 5925	5150– 5925

(FDD Bands)

Operating Band	Uplink (UL) operating band BS receive UE transmit FUL_low - FUL_high (MHz)	Downlink (DL) operating band BS transmit UE receive FUL_low - FUL_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
15	Reserved	Reserved
16	Reserved	Reserved
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
23	2000–2020	2180 –2200
24	1626.5–1660.5	1525 –1559
25	1850–1915	1930 –1995
26	814–849	859 –894
27	807–824	852 –869
28	703–748	758 –803
29	N/A	717 –728
30	2305–2315	2350 – 2360
31	452.5–457.5	462.5– 467.5
32		1452– 1496
65	1920–2010	2110–2200
66	1710–1780	2110–2200
67	N/A	738–758
68	698–728	753–783

3GPP RF Specification

3GPP TS 36.101 V10.22.0 (2016-03)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Evolved Universal Terrestrial Radio Access (E-UTRA);
User Equipment (UE) radio transmission and reception
(Release 10)

3GPP TS 36.104 V13.3.0 (2016-03)

Technical Specification

3rd Generation Partnership Project;
Technical Specification Group Radio Access Network;
Evolved Universal Terrestrial Radio Access (E-UTRA);
Base Station (BS) radio transmission and reception
(Release 13)

02

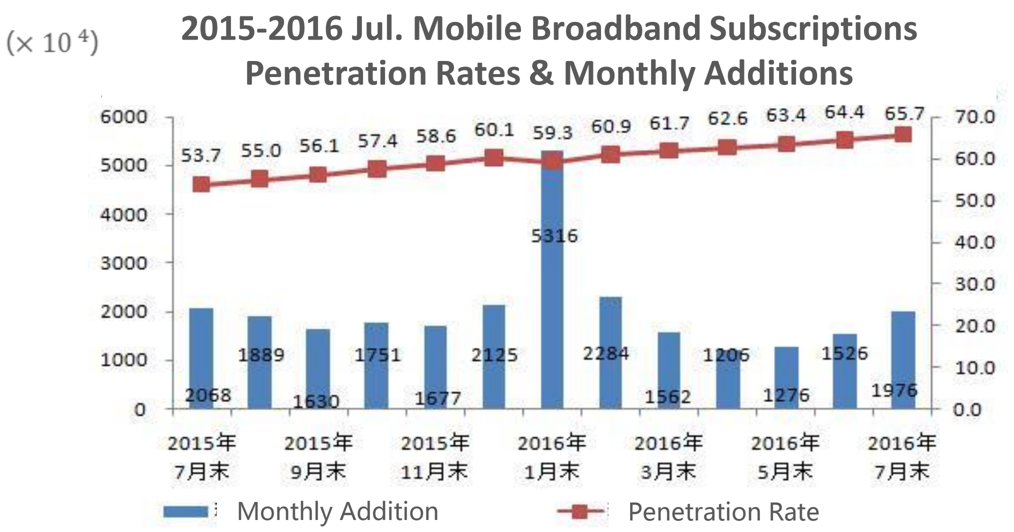
Frequency Planning and Usage of 4G in China

IMT Development

Mobile Subscriptions Sustained Growth & Explosive Increase in 4G subscriptions

By Jul. 2016:

- Total number of mobile subscribers: **1.304 billion**
- Accelerated transition from 2G&3G to 4G. total 4G subscribers: **646 million**, 4G penetration rate: **49.5 %**
- Total mobile broadband (3G&4G) subscriptions: about **858 million**. Mobile broadband penetration rate : **65.7%**
- Statistics by Jul 2016 , **519.2 billion Yuan** income from mobile service in 7 months, increased by **4.5%** comparing to last year.

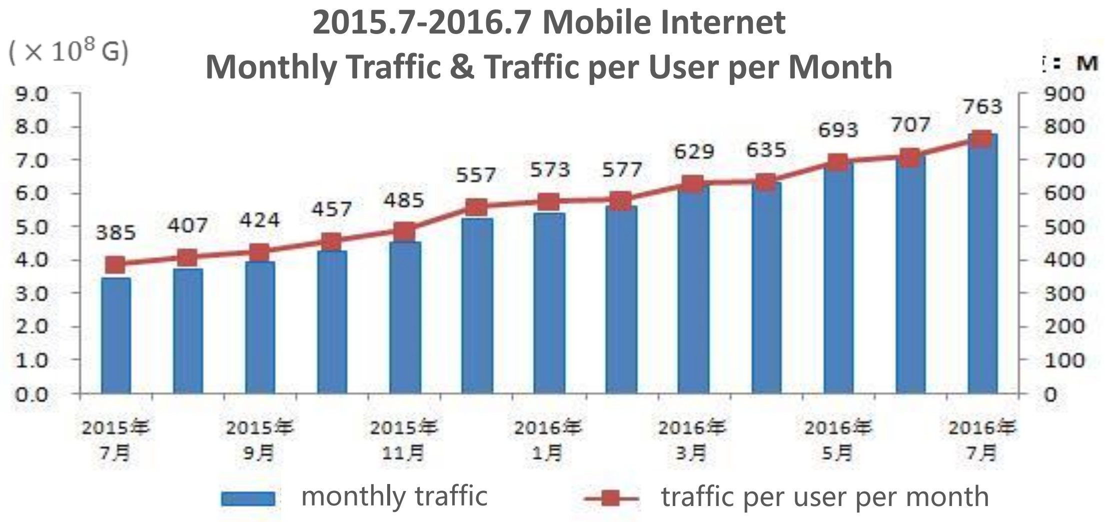


IMT Development

Fast Growth of Mobile Internet Traffic

By Jul. 2016:

- In Jul. total mobile internet access traffic : **7.76 billion GB** , up by **over 123.9 %** comparing to Jul. 2015.
- Average mobile internet traffic per user per month: **763.4MB**
- As the main driver, nearly **89.3%** traffic from phones (the remaining from mobile tablets, USB modem, Mi-Fi router, etc.)



IMT Development

China builds the world’s largest LTE networks

China Mobile launched the first commercial TD-LTE network in China on 18th Dec 2013

- In Dec 2015 CMCC was newly issued 1900-1915MHz band to carry out TD-LTE network.
- By the end of 2015, CMCC has deployed 1.2 million LTE BSs.
- Fast increased TD-LTE subscribers: 429 million by the end of Jun. 2016, contributing more than 70% of all 4G subscribers.

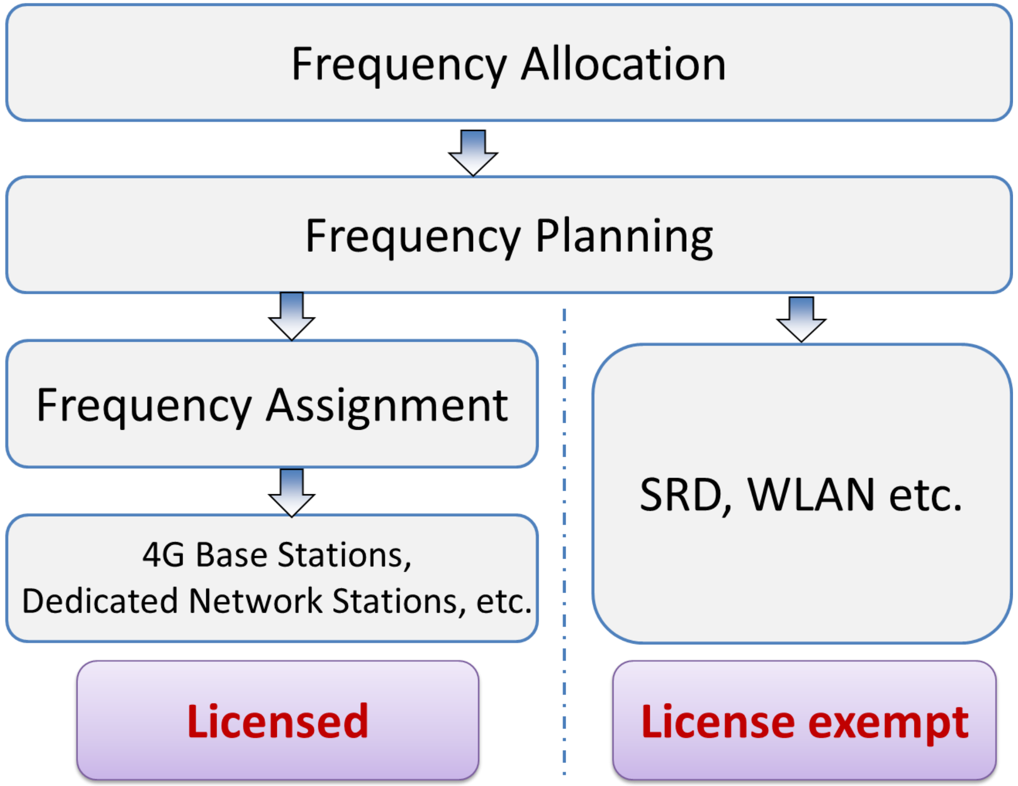
China Telecom launched commercial TD-LTE network on 4th Feb 2014, and was issued FDD-LTE license in Feb 2015

- In Dec 2015, CT was newly issued 1935-1940/2125-2130MHz band to carry out FDD-LTE network
- By the end of 2015, CT has deployed 510k LTE BSs.
- By Jun. 2016, CT 4G subscribers: 90.1 million

China Unicom launched commercial TD-LTE network in first 25 cities on 18th Mar 2014 , and was issued FDD-LTE license in Feb 2015

- By the end of 2015, CU has deployed 400k LTE BSs.
- By Jun. 2016, CU LTE subscribers: 72.7 million

Frequency Management



National Frequency Allocation

- Regulations on the Radio Frequency Allocation of the People's Republic of China (2014)

- Revised and updated according to the ITU Radio Regulations after each WRC. National economy, society, and military factors are taken into account.

IMT Footnotes in China

Frequency band （MHz）	IMT Footnotes
450-470	5.286AA CHN28
698-960	5.313A， 5.317A CHN28
1710-2025	5.384A， 5.388 ,5.388A
2110-2200	5.388, 5.388A
2300-2400	5.384A CHN28
2500-2690	5.384A CHN20
3400-3600	5.432B, 5.433A CHN28

CHN20: From the date of promulgation, research, production and use of new radio stations of radiolocation service shall note be permitted in this band.. The existing radiolocation service stations can be used until to the end of lifetime. During this period, the interference coordination of such radio station should be carried out on a primary basis.

CHN28: In this band, the quoted international footnotes on ITM application do not change the primary or secondary basis of existing services in the allocation table for mobile service. The study should be carried out on applying mode for the planned services， frequency use plan, compatible condition between services and coordination procedure in this band as soon as possible. Erenow, ITM applications are not put into practical operation, but in 2300-2400MHz band, ITM can be permitted to indoor use.

IMT Frequency Planning in China

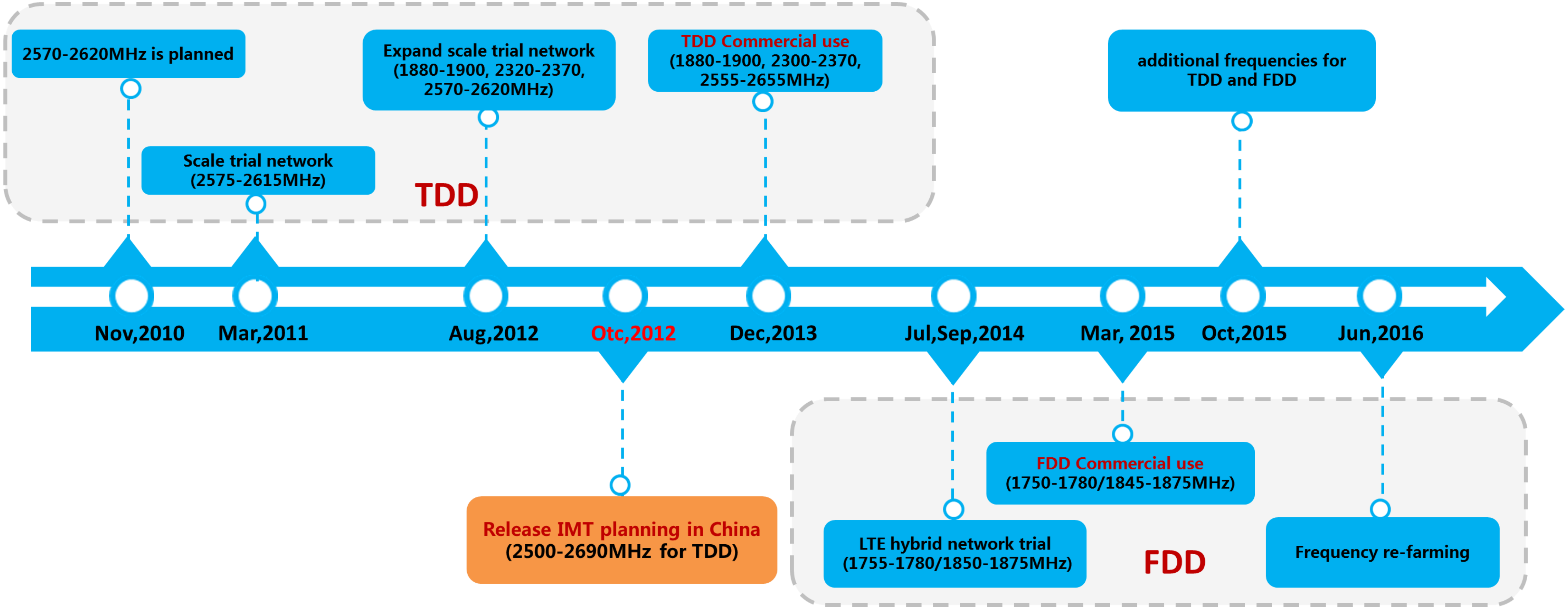
FDD (MHz)	TDD (MHz)	Total BW(MHz)
825-835/870-880	1880-1920	687
889-915/934-960	2010-2025	
1710-1785/1805-1880	2300-2400	
1920-1980/2110-2170	2500-2600	

IMT Frequency Usage in China

Operator	Total BW (MHz)	Network
China Telecom	110	1 CDMA, 1 LTE（TDD/FDD Hybrid)
China Mobile	250	1 GSM, 1 TD-SCDMA, 1 LTE（TD-LTE）
China Unicom	162	1 GSM, 1 WCDMA， 1 LTE （TDD/FDD Hybrid）
Total	**522**	**8**

Frequency Planning and Usage
of 4G in China

4G Frequency Roadmap



4G Frequency Usage in China

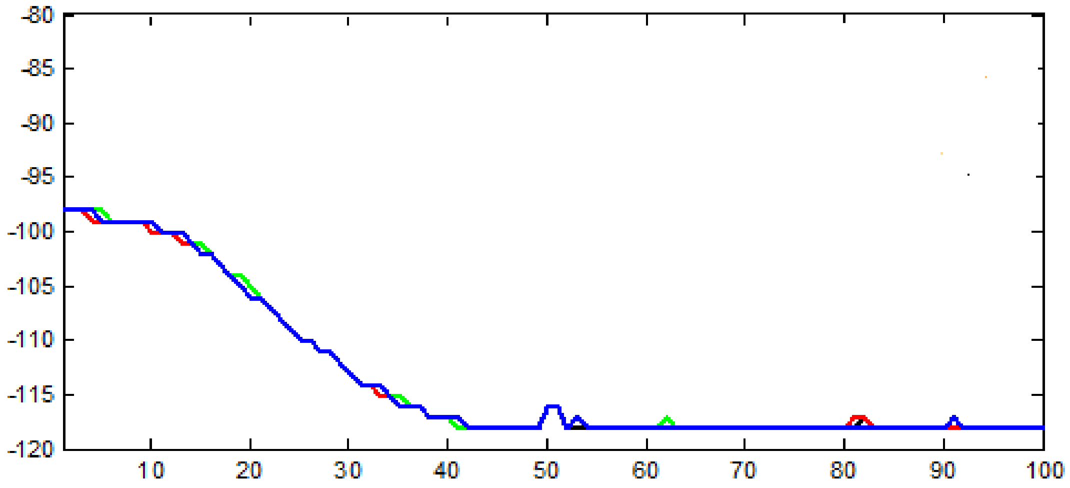
Operator	FDD Bands	Total FDD BW (MHz)	TDD Bands	Total TDD BW (MHz)
China Telecom	825-835/870-880 1765-1780/1860-1875 1920-1940/2110-2130	90	2635-2655	20
China Mobile	--	--	1880-1915 2320-2370 2575-2635	145
China Unicom	909-915/954-960 1750-1765/1845-1860 1955-1965/2145-2155	62	2300-2320 2555-2575	40
Total		152		205

03

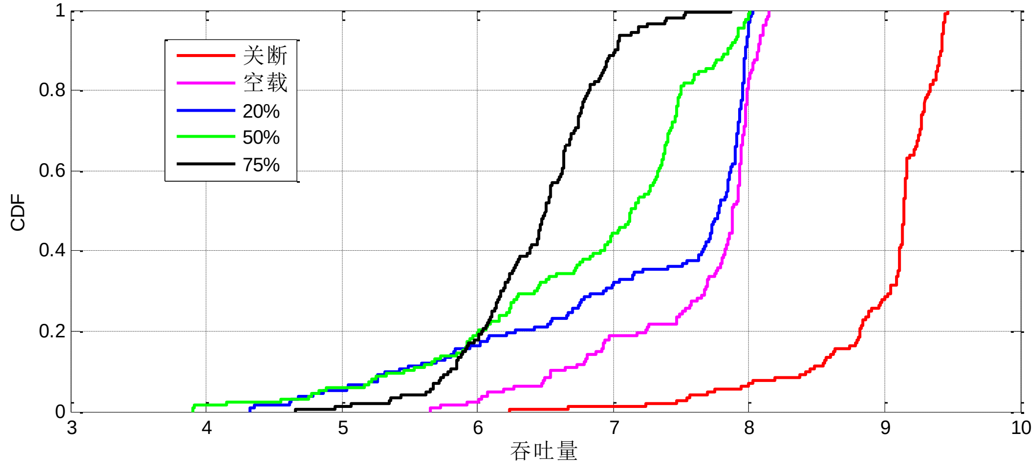
4G Interference Solutions in China

Interference Impact on 4G Systems

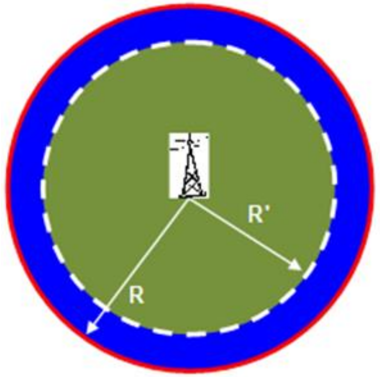
- Background noise increase



- Throughput loss



- Coverage loss



Sources of Interference

- Self-interference
  - ✓ Interference between the cells of deployed networks, such as cross time slot interference, GPS asynchronous interference, interference caused by over coverage
  - ✓ Solutions： optimization of operator networks

Sources of Interference

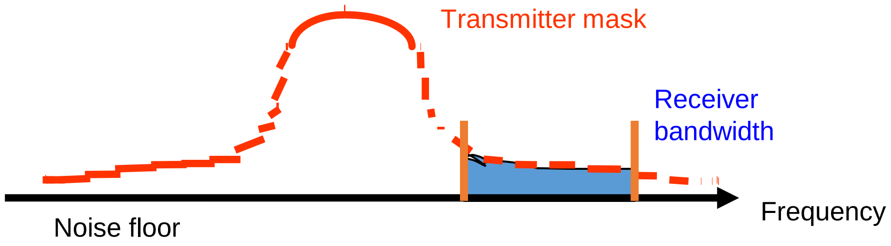
- External-interference
  - ✓ Interference occurred when the LTE bands are illegally used by other systems, or the spurious emission, blocking and intermodulation interference.
- Solutions：
  - ✓ Regulatory documents for frequency management should be appropriately developed and strictly followed.
  - ✓ Interference coordination for deployed networks should be conducted when necessary.

Types of External Interference

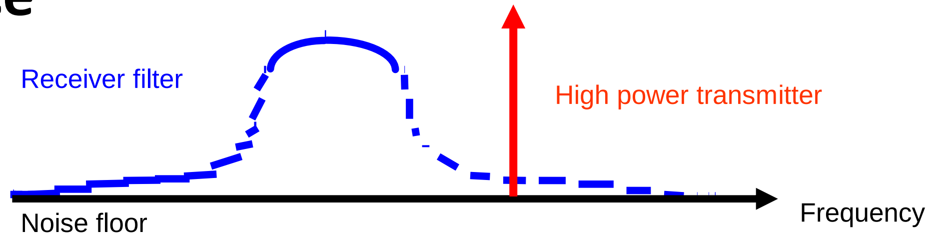
- Co-channel interference
  - ✓ Crosstalk from two different radio transmitters using the same frequency, it can be caused by illegal stations, stations of the neighboring countries in the border areas without coordination, etc.
- Adjacent channel interference
  - ✓ Interference caused by extraneous power from a signal in an adjacent channel;
  - ✓ Out of band, spurious ,blocking, intermodulation interference

4G Interference Solutions in China

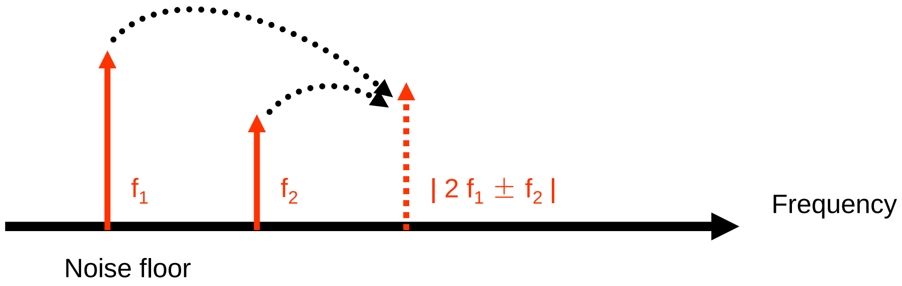
- **spurious interference**



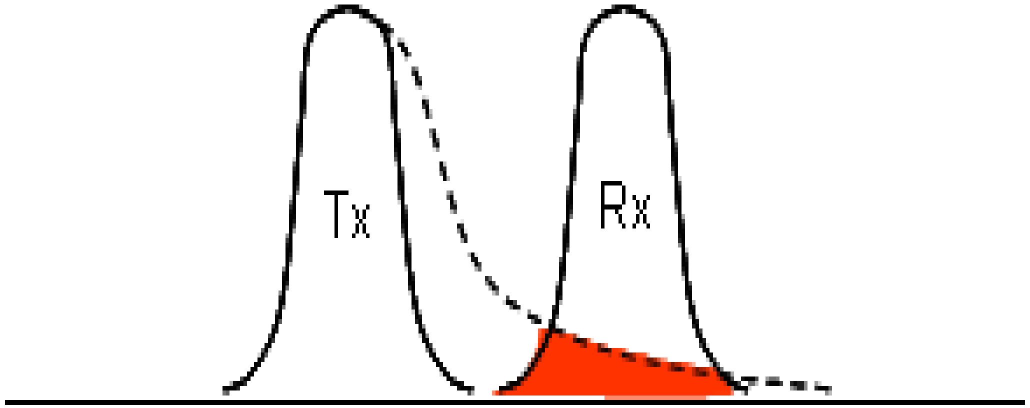
- **Blocking interference**



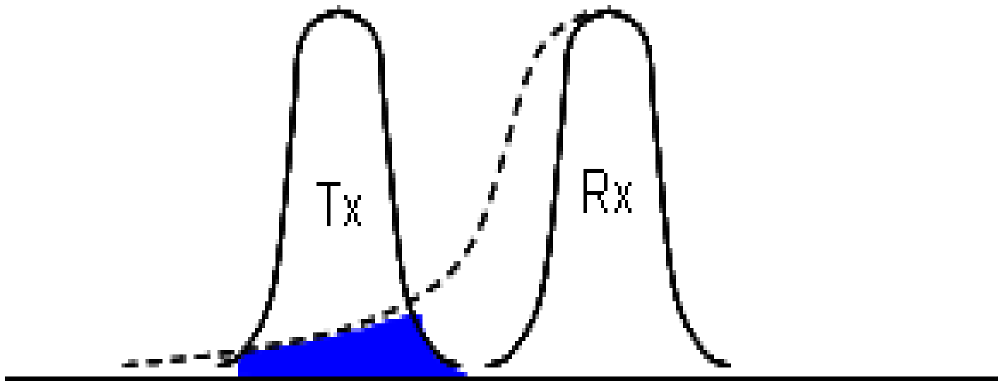
- **Intermodulation interference**



Adjacent Channel Interference



ACLR



ACS

$$\frac{1}{ACIR} = \frac{1}{ACLR} + \frac{1}{ACS}$$

Potential Interference Scenarios

Between LTE and other systems

- Between 1.8GHz LTE and 1800MHz Broadband wireless access system
- Between 1.8GHz LTE and GSM1800
- Between 2.3GHz LTE and WLAN
- Between 2.6GHz LTE and RDSS
- Between 2.6GHz LTE and radar

Between LTE systems

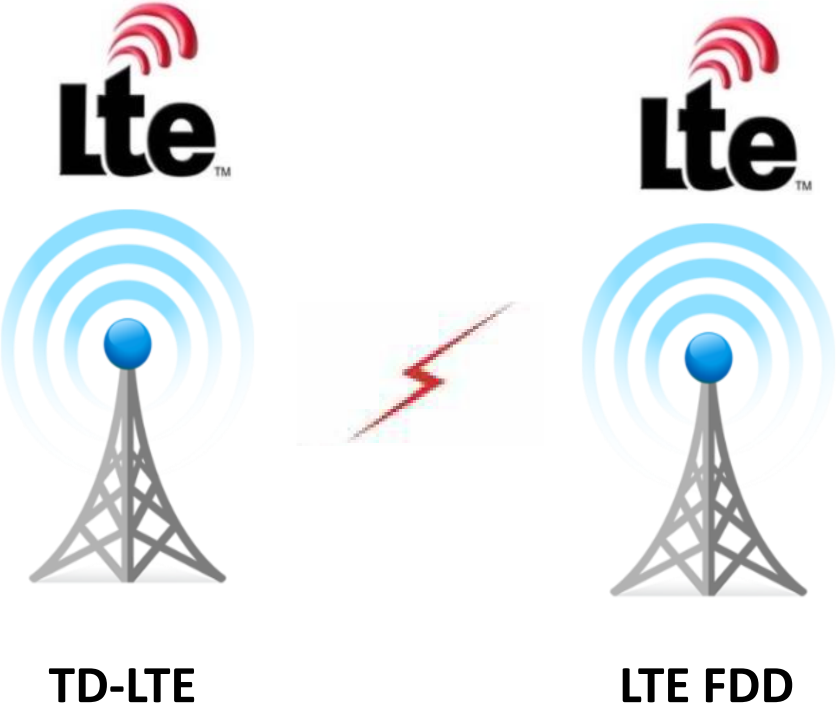
- Between TD-LTE systems in 2.3GHz and 2.6GHz
- Between 1.8GHz、1.9GHz、2.1GHz TD-LTE and LTE FDD

LTE and other Systems

- Methods to eliminate potential interference：
  - ✓ Formulate reasonable RF specifications (transmitter, receiver)
  - ✓ Stations isolation
  - ✓ Set up corresponding guard bands

TD-LTE and LTE FDD Systems

- Mainly refers to the out of band and spurious interference between BS, the interference between user terminals can be ignored.
- The unwanted transmitter power limit (-65dBm/MHz), receiver blocking limit(-5dBm)and minimum coupling loss （50dB） are specified in regulatory documents.
- Set up 5MHz guard bands.



TD-LTE and LTE FDD Systems

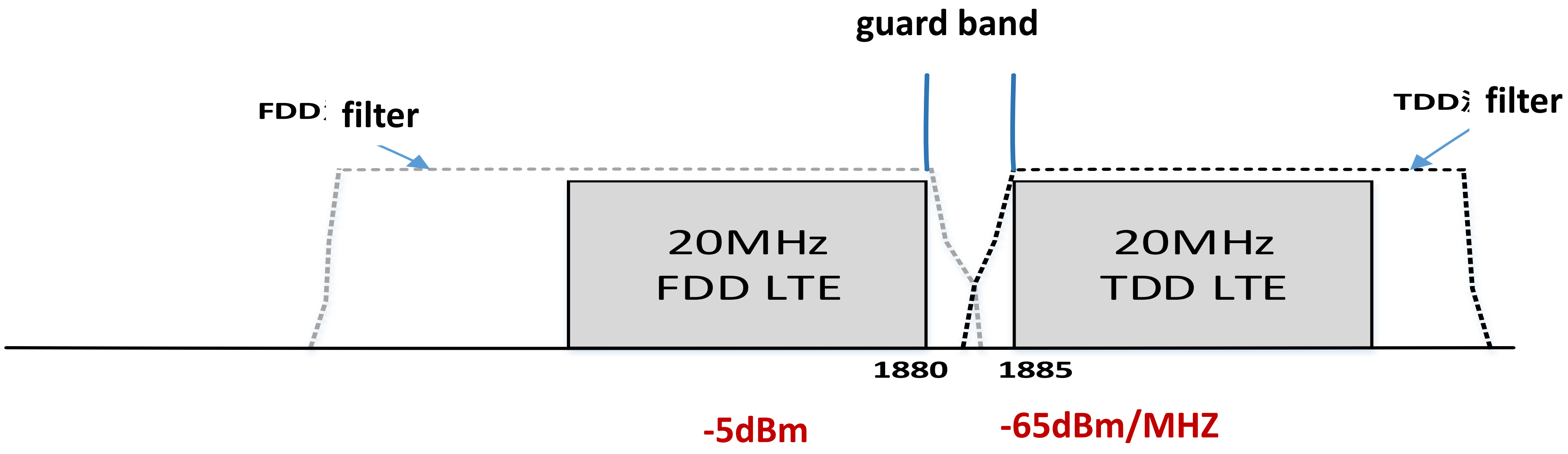
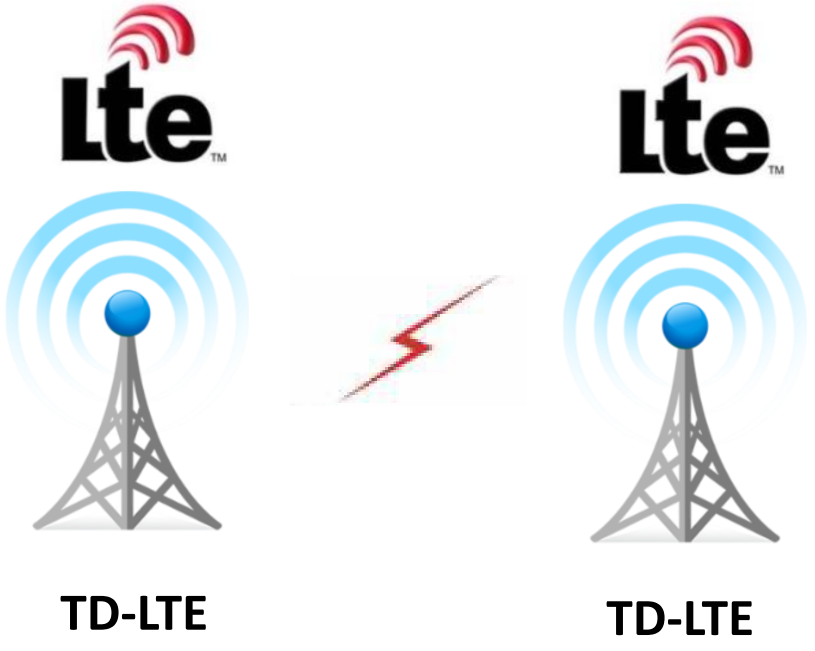


Fig. TDD BS interfered by FDD BS in frequency band 1.8GHz

TD-LTE and TD-LTE Systems

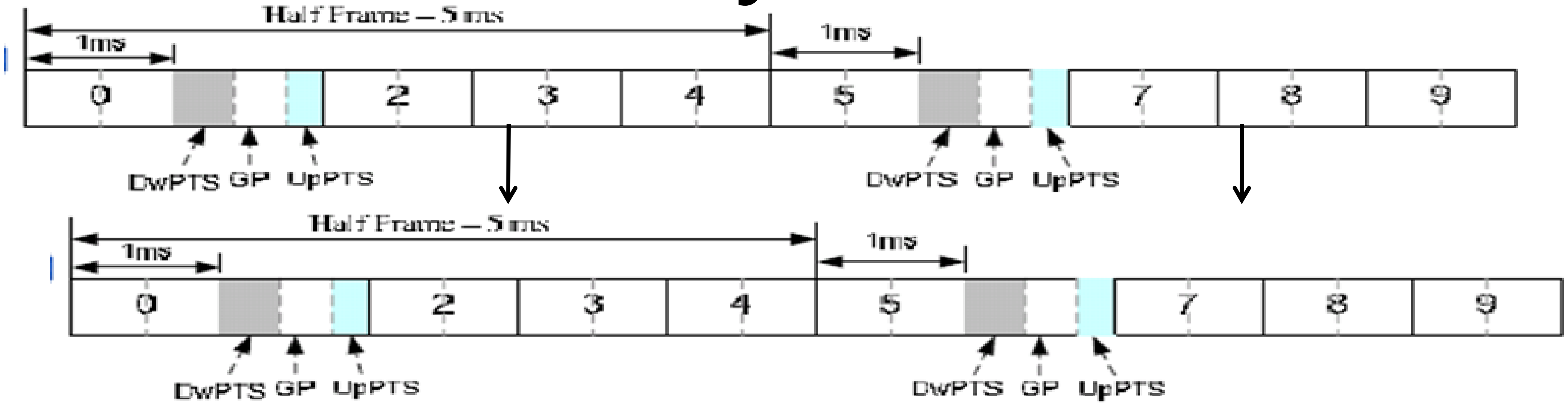
- If the TD-LTE systems are asynchronous and operating in adjacent channels， spurious and blocking interference between BS may occur, especially when the stations are close to each other.



It is stipulated that:

“In order to eliminate interference, time synchronization and the unified time slot ratio should be applied when TD-LTE systems are operating in adjacent channels.”

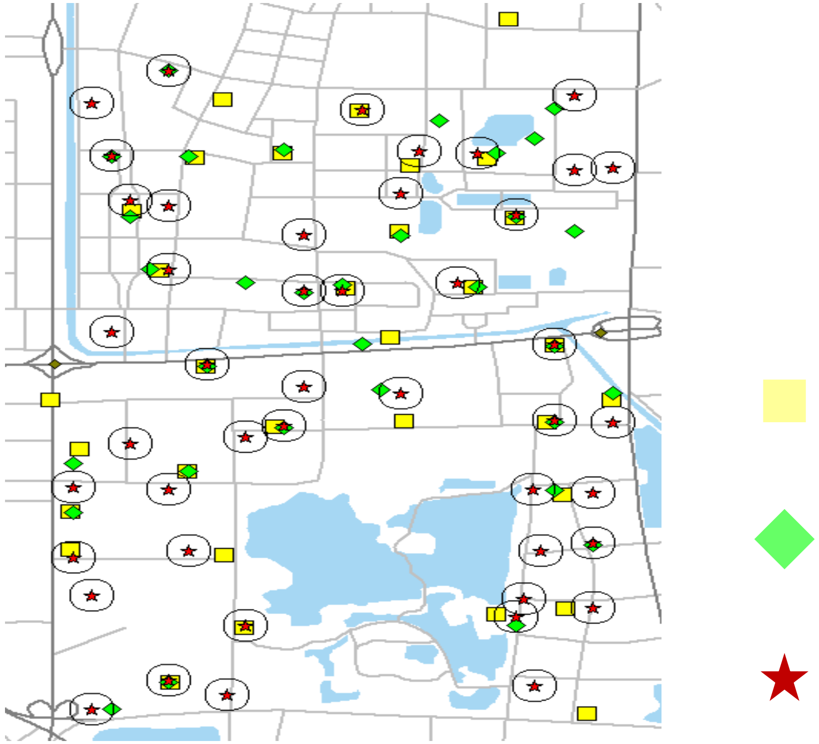
TD-LTE and TD-LTE Systems



Uplink-downlink configuration	Downlink-to-Uplink Switch-point periodicity	Subframe number									
		0	1	2	3	4	5	6	7	8	9
0	5 ms	D	S	U	U	U	D	S	U	U	U
1	5 ms	D	S	U	U	D	D	S	U	U	D
2	5 ms	D	S	U	D	D	D	S	U	D	D
3	10 ms	D	S	U	U	U	D	D	D	D	D
4	10 ms	D	S	U	U	D	D	D	D	D	D
5	10 ms	D	S	U	D	D	D	D	D	D	D
6	5 ms	D	S	U	U	U	D	S	U	U	D

Interference Monitoring Test for 4G

Test area



Base station distribution

Fig. Interference monitoring test in certain area

Interference Monitoring Test for 4G

Step1: Test environment verification

- ✓ LTE FDD: China Telecom, 1765-1780/1860-1875 MHz, 32 base stations, 94 sectors
- ✓ LTE FDD: China Unicom, 1755-1765/1850-1860 MHz, 33 base stations, 99 sectors
- ✓ TD - LTE: China Mobile, 1880-1900 MHz, 45 base stations, 130 sectors
- ✓ Devices in 75 TD-LTE sectors do not satisfy the blocking requirements

- Interference determination criterions
  - ✓ Interference Signal Power ≥-110dBm/RB; (RB: Resource Block)
  - ✓ Number of interfered RB ≥ 10

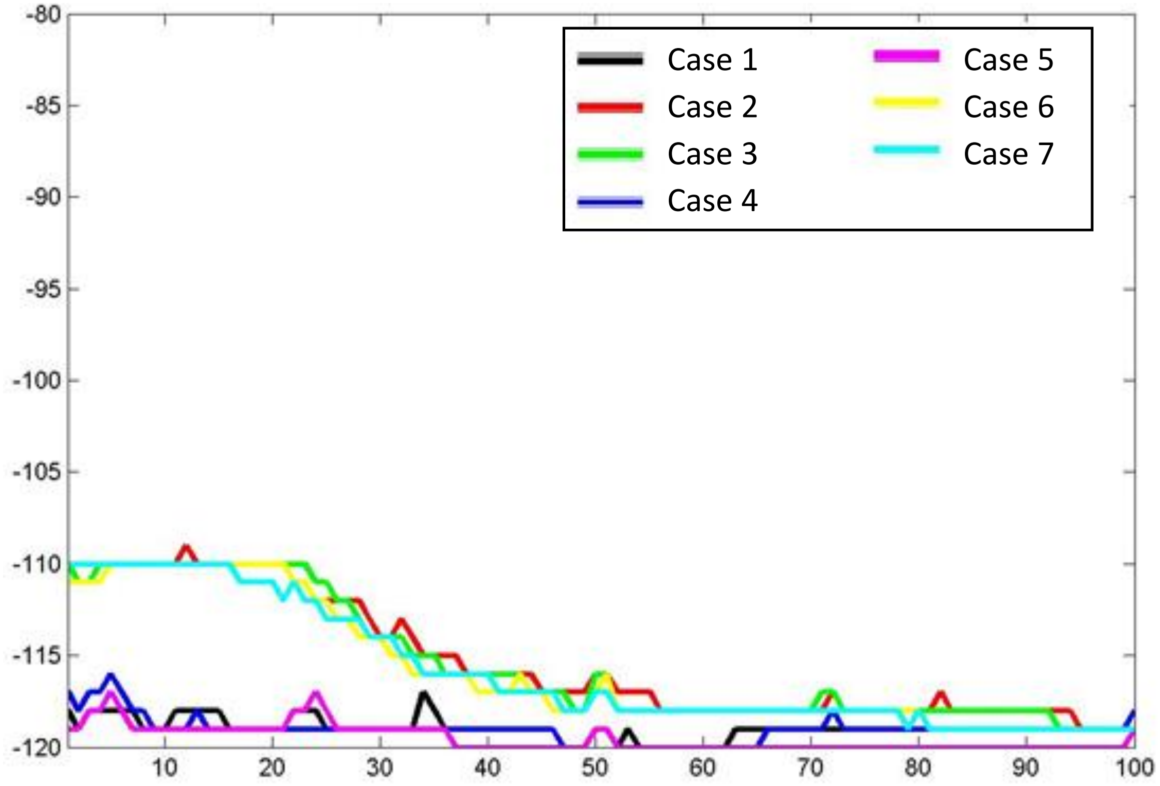
Interference Monitoring Test for 4G

Step2: Interference monitoring cases

- ✓ Case 1: CT and CU BSs power off
- ✓ Case 2: CT BSs 50% virtual load, CU BSs power off
- ✓ Case 3: CT BSs 75% virtual load, CU BSs power off
- ✓ Case 4: CT BSs power off, CU BSs 50% virtual load
- ✓ Case 5: CT BSs power off, CU BSs 75% virtual load
- ✓ Case 6: CT and CU BSs 50% virtual load
- ✓ Case 7: CT and CU BSs 75% virtual load

Interference Monitoring Test for 4G

- Interference caused by CT LTE FDD system



No interference (CT BSs power off)

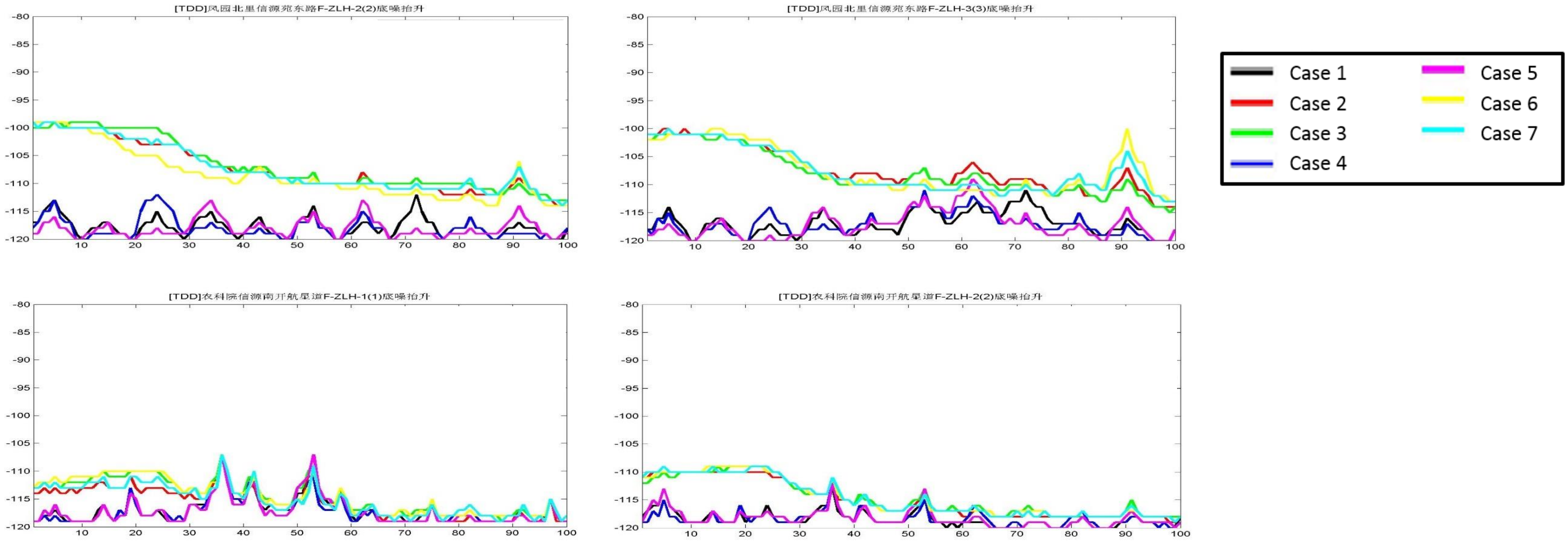
- ✓ Case 1: CT and CU BSs power off
- ✓ Case 4: CT BSs power off, CU BSs 50% virtual load
- ✓ Case 5: CT BSs power off, CU BSs 75% virtual load

Interference (CT BSs power on)

- ✓ Case 2: CT BSs 50% virtual load, CU BSs power off
- ✓ Case 3: CT BSs 75% virtual load, CU BSs power off
- ✓ Case 6: CT and CU BSs 50% virtual load
- ✓ Case 7: CT and CU BSs 75% virtual load

Interference Monitoring Test for 4G

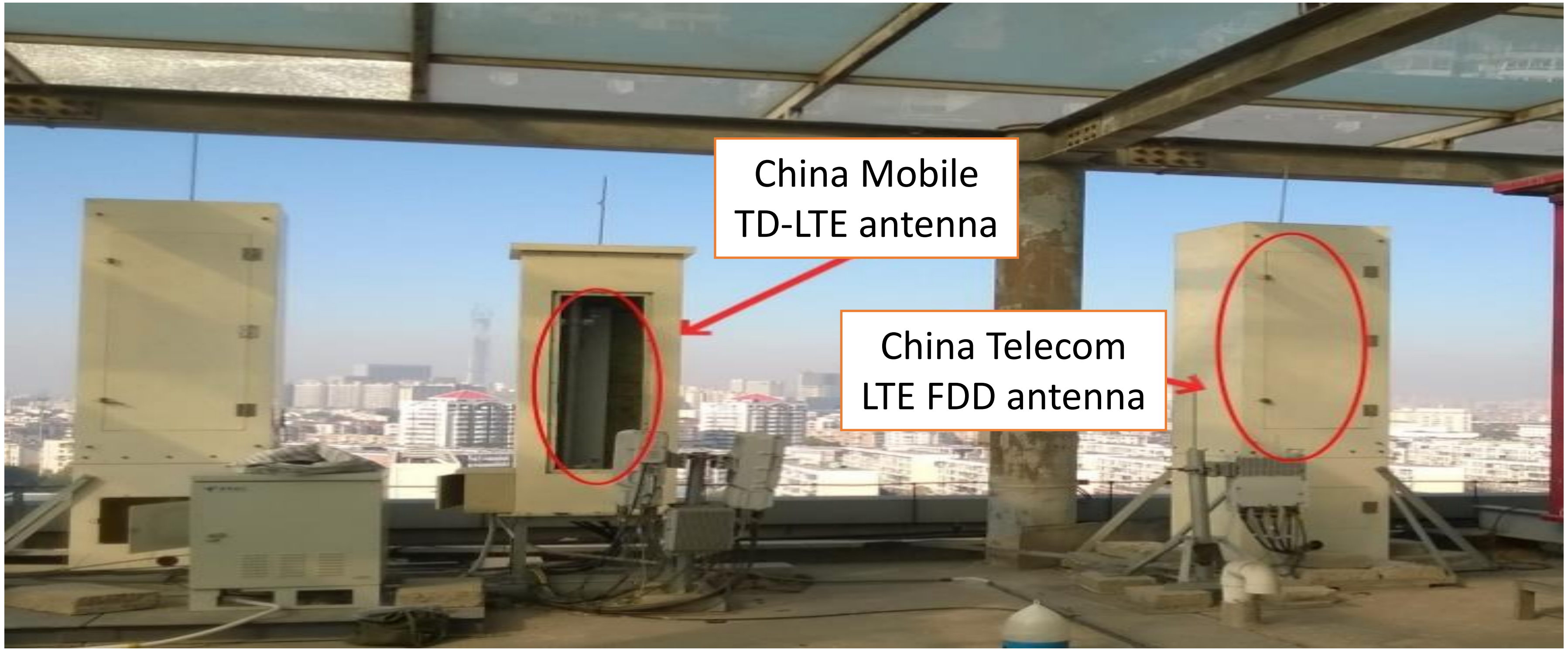
- Interference caused by CT LTE FDD system(5 sectors)



Interference Monitoring Test for 4G

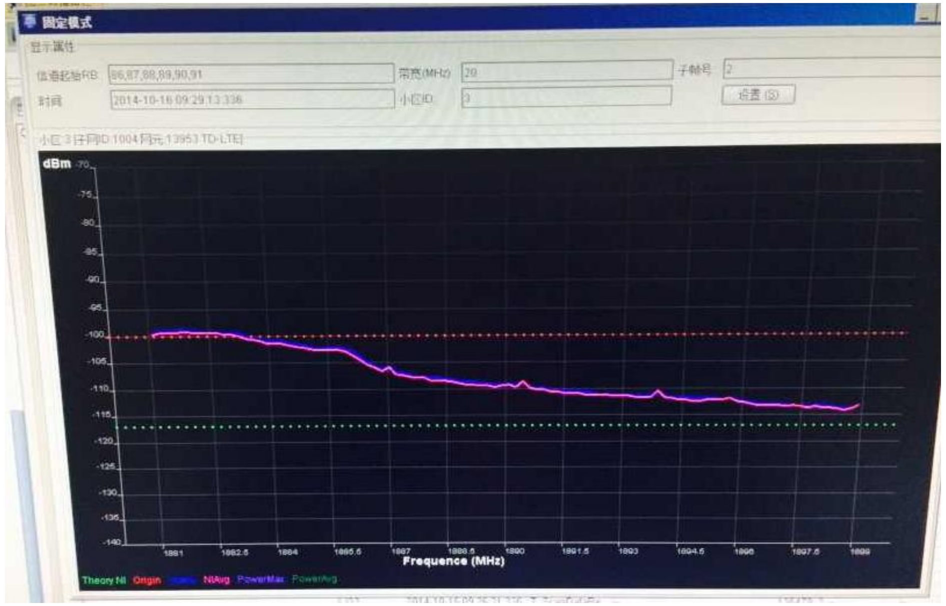
- Step 3: Monitoring test for interference avoidance measures(interfered BS 2 sector 2&3)

Investigation: Position of the two BSs and their antennas

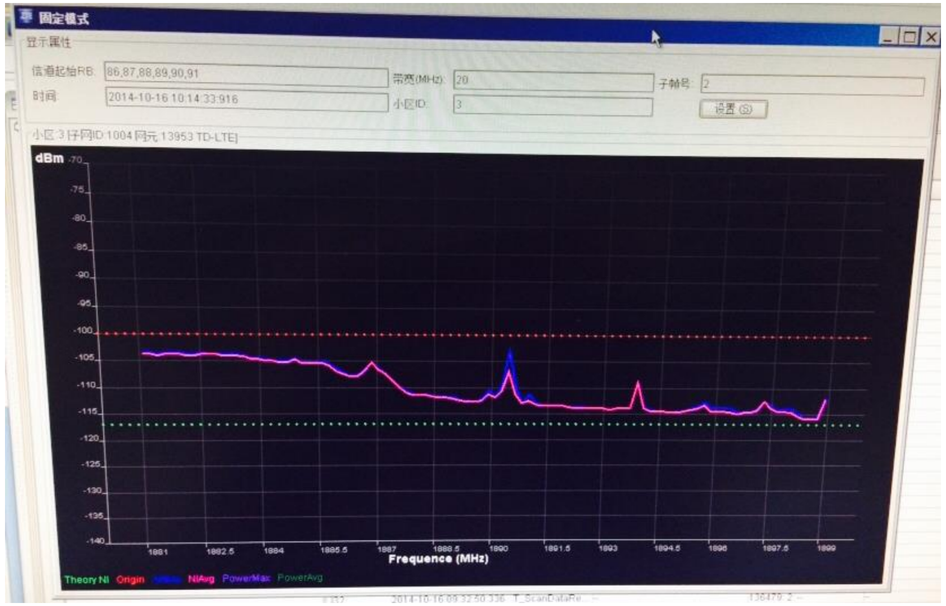


Interference Monitoring Test for 4G

Adjustment： increase the exterior angle between two antenna by 30 degree



Before the adjustment



After the adjustment

Interference mitigated！

Interference Monitoring Test for 4G

- **Monitoring Results**
  - ✓ In the test condition, 5 sectors of 130 TD – LTE sectors operated by China Mobile are interfered.
  - ✓ Interference mainly caused by LTE FDD downlink is operated by China Telecom, while interference from LTE FDD operated by China Unicom has not been found.
- **Conclusion**
  - ✓ Interference can be efficiently mitigated by engineering adjustment measures.

Technical Measures to Mitigate Interference

- Reasonable deployment of stations
- Set protection band
- Isolation of antenna
- Antenna polarization
- Adaptive antenna
- Improvement of transmitter and receiver
- Power control and switching of mobile stations

Summary

- The risk of interference grows with the increase of mobile communication standards, frequency bands and mobile stations.
- The operators need to strengthen communication and coordination on planning and operation of their stations.
- The equipment manufactures and operators are required to strictly comply with the technical specifications.

04

Consideration on Future Frequency Planning

Potential Spectrum for Future IMT

WRC-15 AI 1.1 candidate bands

China supports 3300-3400, 4400-4500 and 4800-4990 MHz bands as potential candidate frequency bands.

2G/3G/4G Re-farming

0 3GHz 6GHz >60GHz

Bands Identified for IMT in the Radio Regulations.

Potential bands above 6 GHz, WRC-19 AI 1.13

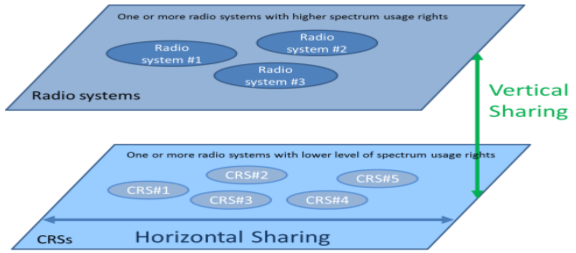
e.g. 450-470MHz,
3400-3600MHz

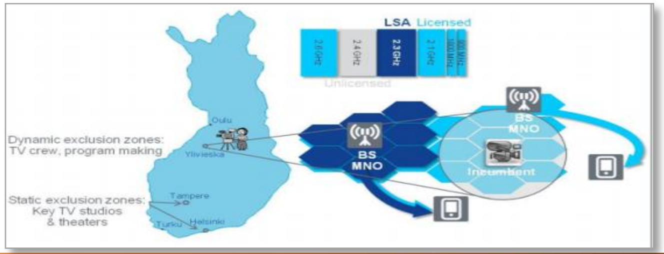
Coordination with railway , satellite etc.

Future Plan in Frequency Bands below 6GHz

New bands for IMT

- 450-470MHz:Coordination with railway communication service
- 3400-3600MHz:Coordination with FSS
- WRC-15 AI 1.1 Bands supported by China : coordination with FS,RLS,AMS
- Other bands : possibly released by digital dividend or by FS migrating to high frequency bands, etc.



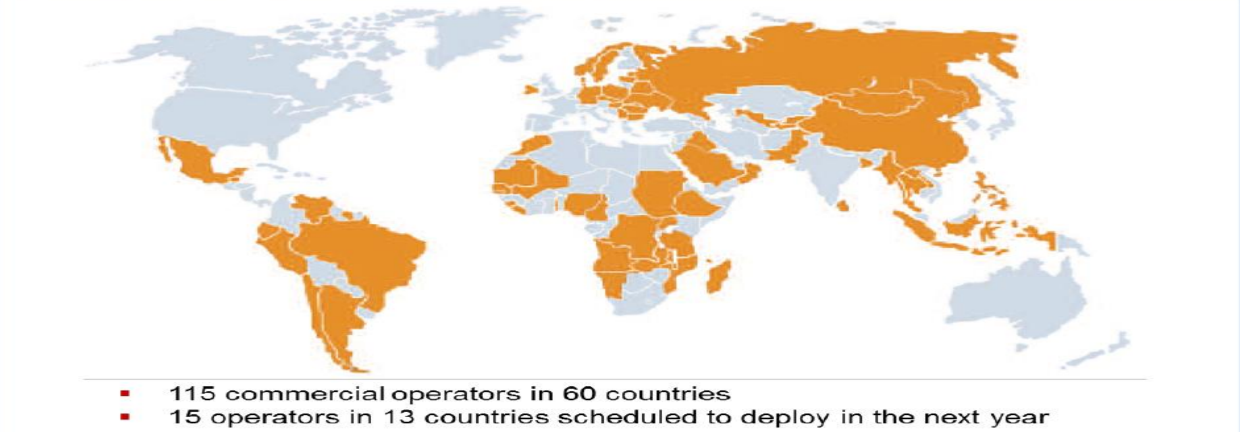


New sharing techniques utilized to resolve co-existences

CRS | **LSA** | **LAA** | **...**

Global Trend of Band 450MHz

Figure 1: CDMA2000 in the 450–470MHz band



- Currently 115 CDMA450 operators in 60 countries. CDMA450 is gradually evolved to LTE450;
- 452.5-457.475MHz/ 462.5-467.475 MHz（3GPP band 31）is the most popular CDMA450 band.

LTE450

- The operator Ukko of Finland has brought the first LTE450 network into commercial use in August, 2014;
- Brazil and Russia have completed LTE450 trial ;
- According to GSA, more than 10 operators have carried out LTE450 trial.

Status of Band 450MHz in China

- Frequency band 450-470MHz is identified as the candidate band for IMT in radio regulations ;
- China Unicom was authorized to carry out LTE450 trial in 3 cities in China last year, which verified the wide coverage characteristic of band 450’ s , especially in rural and remote areas.
- The co-existence of IMT with co-channel systems(such as railway, etc), and with adjacent broadcasting systems should be considered and resolved before frequency planning.

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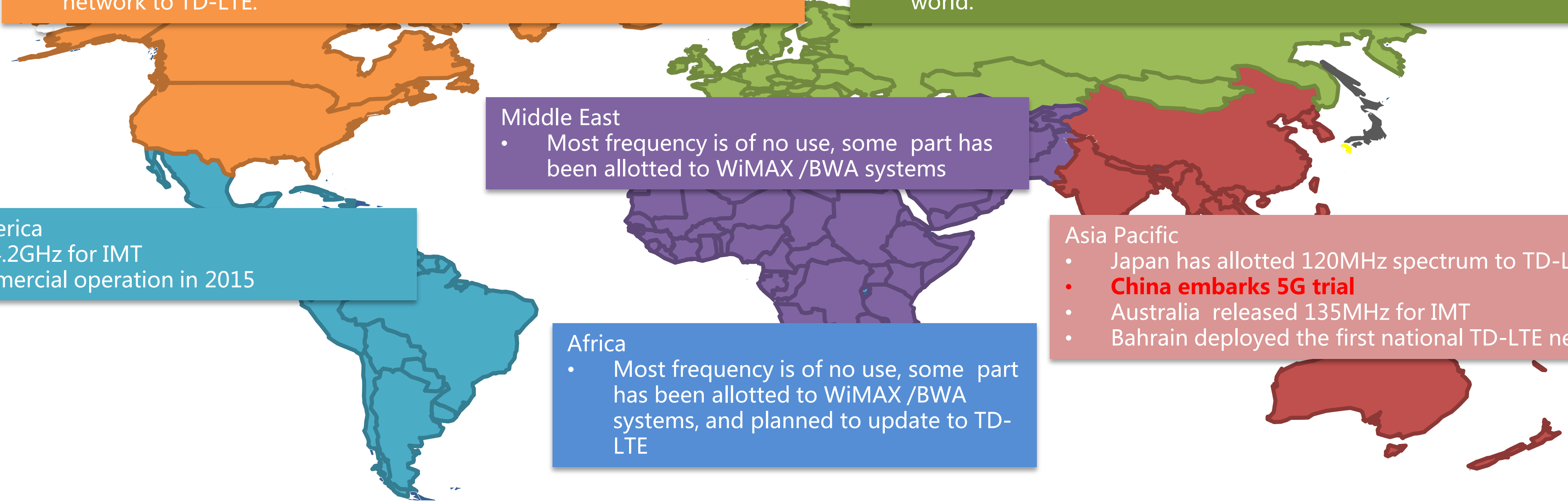
Global Trend of Band 3.5GHz



America
- 50MHz planned in the US
- 150MHz planned in Canada
- 41 operators in South Africa are planning to update their WiMax network to TD-LTE.

Europe
- 3.6-3.8GHz for TDD systems
- 3.4-3.6GHz for TDD systems
- UK deployed the first 3.5GHz TD-LTE commercial network in the world.

Middle East
- Most frequency is of no use, some part has been allotted to WiMAX /BWA systems

Latin America
- 3.5-4.2GHz for IMT
- commercial operation in 2015

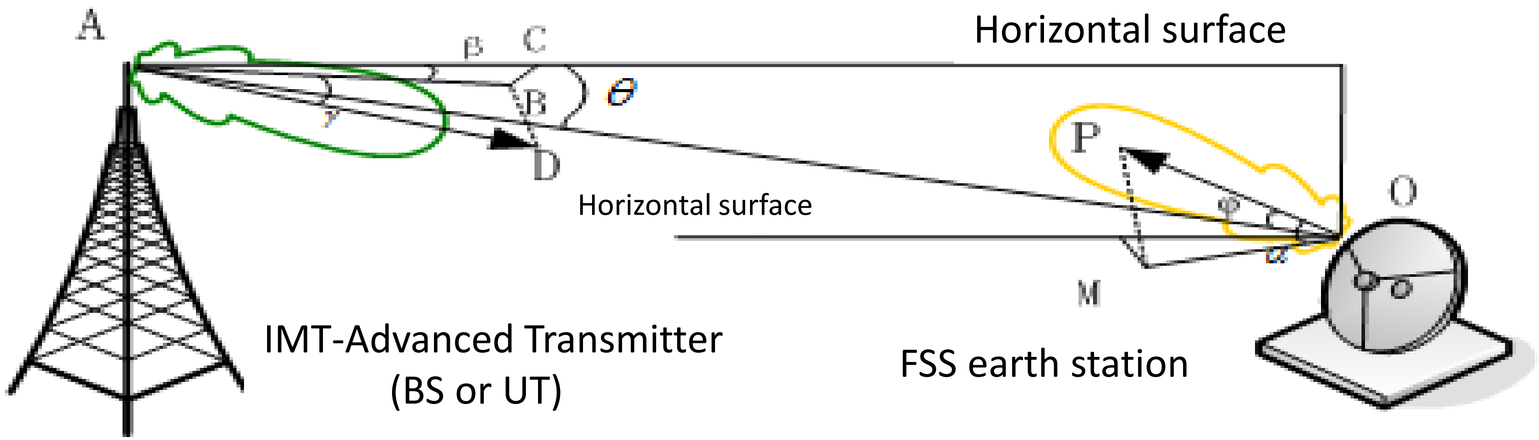
Asia Pacific
- Japan has allotted 120MHz spectrum to TD-LTE
- **China embarks 5G trial**
- Australia released 135MHz for IMT
- Bahrain deployed the first national TD-LTE network

Africa
- Most frequency is of no use, some part has been allotted to WiMAX /BWA systems, and planned to update to TD-LTE

In 2013-2014, frequency management agencies such as the European CEPT, the British ofcom, Australian ACMA consulting, American FCC, Canadian IC and South African ICASA have investigated the TDD planning proposition in 3400-3600MHz.

Status of band 3.5GHz in China

- CHN28 stipulates that in this band, the quoted international footnotes on IMT application do not change the primary or secondary basis of existing services in the allocation table for mobile use.
- The co-existence of IMT with incumbent fixed satellite service should be considered and resolved.



WRC-15 AI 1.1 Bands in China

China launched revision of P.R.CHINA Regulations on the Radio Frequency Allocation

— On April 22nd 2016, the first meeting on revision of P.R.CHINA Regulations on the Radio Frequency Allocation was held in Beijing.

◆ **Proposals related to IMT was introduced and discussed:**

Spectrum Band	Proposal
3300-3400MHz	● ADD new CHN Footnote to bring IMT in
4400-4500MHz	● ADD new CHN Footnote to bring IMT in
4800-4990MHz	● ADD new CHN Footnote to bring IMT in
……	……

- **Considering various incumbent radio systems, coordination groups for each band above were set up to further study the feasibility of revision.**
- **The revision will be finalized by the end of 2016.**

Digital Dividend

A global trend： terrestrial television digital switchover & digital dividend band freed up for IMT

1. Digital switchover enormously improves spectrum utilization efficiency

2. Digital dividend spectrum utilized by IMT generates more economy benefits

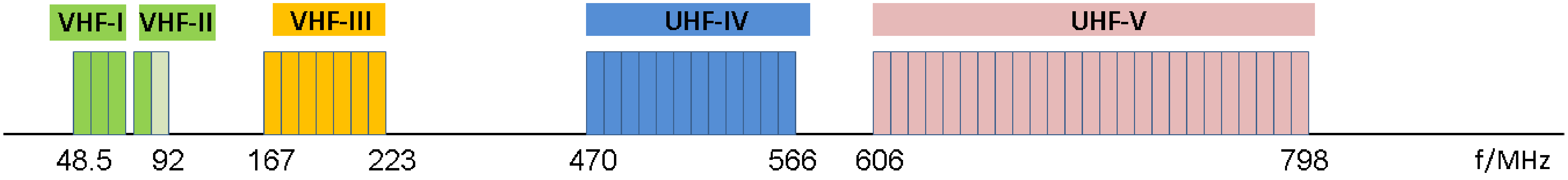
3. 700MHz band is the “GOLD” band for mobile industry

Global status of TV Analogue-Digital Switchover

- Based on ITU News Magazine (April 2015) , by then ,most countries in North America and Europe and part of Asia have obsoleted analogue TV
- Most countries in Latin America and Asia-pacific region have made plans for finalizing digital switchover in 2015-2020
- Most developed countries (US, Germany, Sweden, Portuguesa, Spain, France, Japan, Netherland, Canada, etc.) have finalized analogue to digital switchover as early as 2012

Broadcasting Services in China

- Frequency bands：Medium wave 535-1606.5kHz AM
  - Short wave 5900-26100kHz AM
  - Ultrashort wave 88-108MHz FM
  - Ultrashort wave 48.5-798MHz TV 48 Channels（CH5 not used）



BAND	FREQUENCY	CHANNEL	WAVEBAND
BAND I	48.5MHz-72.5MHz	DS1-DS3	VHF
BAND II	76MHz-92MHz	DS4-DS5	VHF
BAND III	167MHz-175MHz	DS6-DS12	HF
BAND IV	470MHz-566MHz	DS13-DS24	UHF
BAND V	606MHz-798MHz	DS25-DS48	UHF

Status of TV Analogue-Digital Switchover in China

- China released "Terrestrial Digital TV Overlay Network Development Plan" in late 2012, which demonstrated 3-steps strategy:

2013-2015

Above the city level, to finalize digital switchover

By 2018

Above the county level, to achieve digital terrestrial broadcasting in Standard and HD

By 2020

To finalize digital switchover in the whole country

(Trainer information)

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Photo：

Thanks!

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