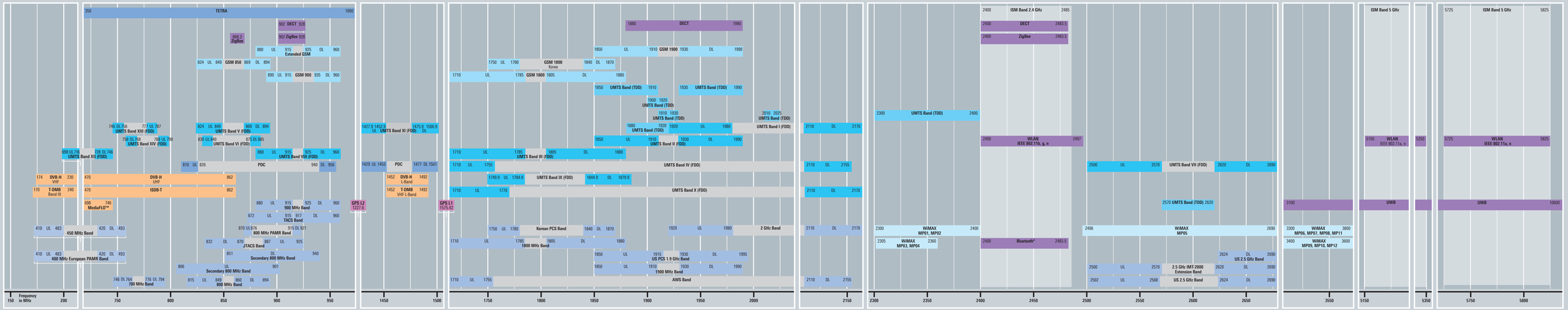
Wireless Communications Standards



DIGITAL CELLULAR STANDARDS

3GPP LTE

Frequency range

UMTS Bands (FDD)

- **I)** UL: 1920 MHz to 1980 MHz; DL: 2110 MHz to 2170 MHz
- **II)** UL: 1850 MHz to 1910 MHz; DL: 1930 MHz to 1990 MHz
- **III)** UL: 1710 MHz to 1785 MHz; DL: 1805 MHz to 1880 MHz
- **IV)** UL: 1710 MHz to 1755 MHz; DL: 2110 MHz to 2155 MHz
- **V)** UL: 824 MHz to 849 MHz; DL: 869 MHz to 894 MHz
- **VI)** UL: 830 MHz to 840 MHz; DL: 875 MHz to 885 MHz
- **VII)** UL: 2500 MHz to 2570 MHz; DL: 2620 MHz to 2690 MHz
- **VIII)** UL: 880 MHz to 915 MHz; DL: 925 MHz to 960 MHz
- **IX)** UL: 1749.9 MHz to 1784.9 MHz; DL: 1844.9 MHz to 1879.9 MHz
- **X)** UL: 1710 MHz to 1770 MHz; DL: 2110 MHz to 2170 MHz
- **XI)** UL: 1427.9 MHz to 1452.9 MHz; DL: 1475.9 MHz to 1500.9 MHz
- **XII)** UL: 698 MHz to 716 MHz; DL: 728 MHz to 746 MHz
- **XIII)** UL: 777 MHz to 787 MHz; DL: 746 MHz to 756 MHz
- **XIV)** UL: 788 MHz to 798 MHz; DL: 758 MHz to 768 MHz

Modulation

UL: QPSK, 16QAM, 64QAM
DL: QPSK, 16QAM, 64QAM

Multiple access

OFDMA (DL)
SC-FDMA (UL)

Duplex (uplink/downlink)

TDD / FDD

Channel bandwidth

Scalable to 20 MHz

Peak data rate

172 Mbit/s
(DL, 20 MHz, 2×2 MIMO)
86 Mbit/s
(UL, 20 MHz)

3GPP WCDMA/ HSPA/ HSPA+

Frequency range

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Modulation

UL: QPSK, 16QAM, 64QAM (HSPA+)
DL: QPSK, 16QAM (HSDPA), 64QAM (HSPA+)

Multiple access

WCDMA

Duplex (uplink/downlink)

FDD

Channel bandwidth

5 MHz

Peak data rate

2 Mbit/s
14 Mbit/s (DL, HSDPA)
28 Mbit/s (DL, HSPA+)
5.76 Mbit/s (UL, HSUPA)
11 Mbit/s (UL, HSPA+)

3GPP TD-SCDMA

Frequency range

UMTS Bands (TDD)

1900 MHz to 1920 MHz
2010 MHz to 2025 MHz
1850 MHz to 1910 MHz
1930 MHz to 1990 MHz
1910 MHz to 1930 MHz
2570 MHz to 2620 MHz
1880 MHz to 1920 MHz
2300 MHz to 2400 MHz

Modulation

QPSK, 8PSK
16QAM (HSPA only)

Multiple access

TD-SCDMA

Duplex (uplink/downlink)

TDD

Channel bandwidth

1.6 MHz

Peak data rate

2 Mbit/s
2.8 Mbit/s (HSPA)

3GPP TD-CDMA

Modulation

UL+DL: QPSK
DL: 16QAM (HSDPA only)

Multiple access

TD-CDMA

Duplex (uplink/downlink)

TDD

Channel bandwidth

5 MHz

Peak data rate

2 Mbit/s
10 Mbit/s (HSDPA)

GSM/GPRS/EDGE/ EDGE Evolution

Frequency range

GSM 850
UL: 824 MHz to 849 MHz
DL: 869 MHz to 894 MHz

GSM 900
UL: 890 MHz to 915 MHz
DL: 935 MHz to 960 MHz

E-GSM
UL: 880 MHz to 915 MHz
DL: 925 MHz to 960 MHz

GSM 1800
UL: 1710 MHz to 1785 MHz
DL: 1805 MHz to 1880 MHz

Korea:
UL: 1750 MHz to 1780 MHz
DL: 1840 MHz to 1870 MHz

GSM 1900
UL: 1850 MHz to 1910 MHz
DL: 1930 MHz to 1990 MHz

Modulation

GMSK, 8PSK (EDGE only), QPSK, 16QAM, 32QAM (EDGE evolution only)

Multiple access

TDMA / FDMA

Duplex (uplink/downlink)

FDD

Channel bandwidth

200 kHz

Peak data rate

14.4 kbit/s (GSM)
53.6 kbit/s (GPRS)
384 kbit/s (EDGE)
1 Mbit/s (EDGE evolution)

WiMAX™

IEEE 802.16e-2005
IEEE 802.16-2004

Frequency range

Profiles
MP01, MP02:
2300 MHz to 2400 MHz
MP03, MP04:
2305 MHz to 2360 MHz
MP05:
2496 MHz to 2690 MHz
MP06, MP07:
3300 MHz to 3400 MHz
MP08, MP11:
3400 MHz to 3800 MHz
MP09, MP10, MP12:
3400 MHz to 3600 MHz

Targeted:
IMT-2000 Bands (TDD)

Modulation

BPSK, QPSK, 16QAM, 64QAM, SC

Multiple access

SOFDMA (128, 256, 512, 1024, 2048); OFDM 256, SC

Duplex (uplink/downlink)

TDD // FDD)

Channel bandwidth

5 MHz, 7 MHz, 8.75 MHz, 10 MHz dependent on profile; IEEE 802.16: 1.25 MHz to 28 MHz

Peak data rate

114 Mbit/s
(DL, 20 MHz, 2×2 MIMO, TDD)
(16e)

UMB

Frequency range

Band Classes (in MHz)
BC0) 800 MHz Band
UL: 815 to 849, DL: 860 to 894
BC1) 1900 MHz Band
UL: 1850 to 1910, DL: 1930 to 1990
BC2) TACS Band
UL: 872 to 915, DL: 917 to 960
BC3) JTACS Band
UL: 887 to 925, DL: 832 to 870
BC4) Korean PCS Band
UL: 1750 to 1780, DL: 1840 to 1870
BC5) 450 MHz Band
UL: 410 to 483, DL: 420 to 493
BC6) 2 GHz Band
UL: 1920 to 1980, DL: 2110 to 2170
BC7) 700 MHz Band
UL: 776 to 794, DL: 746 to 764
BC8) 1800 MHz Band
UL: 1710 to 1785, DL: 1805 to 1880
BC9) 900 MHz Band
UL: 880 to 915, DL: 925 to 960
BC10) Secondary 800 MHz Band
UL: 806 to 901, DL: 851 to 940
BC11) 400 MHz European PAMR Band
UL: 410 to 483, DL: 420 to 493
BC12) 800 MHz PAMR Band
UL: 870 to 876, DL: 915 to 921
BC13) 2.5 GHz IMT-2000 Extension Band
UL: 2500 to 2570, DL: 2620 to 2690
BC14) US PCS 1.9 GHz Band
UL: 1850 to 1915, DL: 1930 to 1995
BC15) AWS Band
UL: 1710 to 1755, DL: 2110 to 2155
BC16) US 2.5 GHz Band
UL: 2502 to 2568, DL: 2624 to 2690
BC17) US 2.5 GHz Forward Link Only Band
DL: 2624 to 2690

CDMA2000® 1xEV-DO Revision B

Modulation

Forward: QPSK, 16QAM, 64QAM, HPSK
Reverse: QPSK, 16QAM, 64QAM, HPSK

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

HPSK

Channel bandwidth

1.25 to 20 MHz

Peak data rate

4.9 Mbit/s × N (forward)
1.9 Mbit/s × N (reverse)
N = channel with 1.25 MHz bandwidth

CDMA2000® 1xEV-DO Release 0/Revision A

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

HPSK

Channel bandwidth

1.25 MHz × N (N = number of channels)

Peak data rate

Release 0:
2.4 Mbit/s (forward)
153 kbit/s (reverse)
Revision A:
3.1 Mbit/s (forward)
1.8 Mbit/s (reverse)

CDMA2000® 1xRTT

Frequency range

Band Classes (in MHz)
BC0) 800 MHz Band
UL: 815 to 849, DL: 860 to 894
BC1) 1900 MHz Band
UL: 1850 to 1910, DL: 1930 to 1990
BC2) TACS Band
UL: 872 to 915, DL: 917 to 960
BC3) JTACS Band
UL: 887 to 925, DL: 832 to 870
BC4) Korean PCS Band
UL: 1750 to 1780, DL: 1840 to 1870
BC5) 450 MHz Band
UL: 410 to 483, DL: 420 to 493
BC6) 2 GHz Band
UL: 1920 to 1980, DL: 2110 to 2170
BC7) 700 MHz Band
UL: 776 to 794, DL: 746 to 764
BC8) 1800 MHz Band
UL: 1710 to 1785, DL: 1805 to 1880
BC9) 900 MHz Band
UL: 880 to 915, DL: 925 to 960
BC10) Secondary 800 MHz Band
UL: 806 to 901, DL: 851 to 940
BC11) 400 MHz European PAMR Band
UL: 410 to 483, DL: 420 to 493
BC12) 800 MHz PAMR Band
UL: 870 to 876, DL: 915 to 921
BC13) 2.5 GHz IMT-2000 Extension Band
UL: 2500 to 2570, DL: 2620 to 2690
BC14) US PCS 1.9 GHz Band
UL: 1850 to 1915, DL: 1930 to 1995
BC15) AWS Band
UL: 1710 to 1755, DL: 2110 to 2155
BC16) US 2.5 GHz Band
UL: 2502 to 2568, DL: 2624 to 2690

Modulation

QPSK, OQPSK, HPSK

Multiple access

CDMA

Duplex (uplink/downlink)

FDD

Channel bandwidth

1.25 MHz

Peak data rate

307.7 kbit/s

cdmaOne IS-95

Frequency range

UL: 824 MHz to 849 MHz
DL: 869 MHz to 894 MHz

UL: 1850 MHz to 1910 MHz
DL: 1930 MHz to 1990 MHz

Modulation

QPSK/OQPSK

Multiple access

CDMA / FDMA

Duplex (uplink/downlink)

FDD

Channel bandwidth

1.25 MHz

Peak data rate

14.4 kbit/s (IS-95-A)
115.2 kbit/s (IS-95-B)

IS-136

Frequency range

IS-54 and IS-136
UL: 824 MHz to 849 MHz
DL: 869 MHz to 894 MHz

IS-136
UL: 1850 MHz to 1910 MHz
DL: 1930 MHz to 1990 MHz

Modulation

π/4 DQPSK

Multiple access

TDMA / FDMA

Duplex (uplink/downlink)

FDD

Channel bandwidth

30 kHz

Peak data rate

13.2 kbit/s (IS-54)
28.8 kbit/s
(43.2 kbit/s)

PDC

Frequency range

UL: 810 MHz to 826 MHz
DL: 940 MHz to 956 MHz

UL: 1429 MHz to 1453 MHz
DL: 1477 MHz to 1501 MHz

Modulation

π/4 DQPSK

Multiple access

TDMA / FDMA

Duplex (uplink/downlink)

FDD

Channel bandwidth

25 kHz

Peak data rate

42 kbit/s

TETRA

Frequency range

350 MHz to 1000 MHz

Modulation

π/4 DQPSK

Multiple access

TDMA

Duplex (uplink/downlink)

FDD

Channel bandwidth

25 kHz

Peak data rate

7.2 kbit/s
28.8 kbit/s using timeslot bundling

MBWA (Mobile Broadband Wireless Access) IEEE 802.20

Frequency range

0.5 GHz to 3.5 GHz

Modulation

BPSK, QPSK, 8PSK, 12QAM, 16QAM, 24QAM, 32QAM, 64QAM

Multiple access

OFDMA (512, 1024, 2048)

Duplex (uplink/downlink)

TDD / FDD

Channel bandwidth

1.25 MHz, <5 MHz
635 kHz/carrier in MC mode

Peak data rate

>4 Mbit/s (1.25 MHz), >16 Mbit/s (5 MHz)

Cognitive Radio IEEE 802.22

Frequency range

Max. Range:
54 MHz to 862 MHz

54 MHz to 746 MHz (North America)
48 MHz to 798 MHz (Europe)
48 MHz to 798 MHz (China)
54 MHz to 746 MHz (Japan)

Modulation

OFDM, OFDMA (1000 carriers) (8000 carriers with on-channel repeaters)

Multiple access

OFDM, CSMA/CA

Duplex (uplink/downlink)

OFDM, CSMA/CA

Channel bandwidth

6 MHz, 7 MHz, 8 MHz

Peak data rate

72 Mbit/s

WIRELESS CONNECTIVITY

WLAN IEEE 802.11a, b, g

Frequency range

2.4 GHz to 2.497 GHz (b, g, n)
5.15 GHz to 5.35 GHz (a, n)
5.725 GHz to 5.825 GHz (a, n)

Modulation

BPSK, QPSK, 16QAM, 64QAM, CCK, PBCC

Multiple access

OFDM, CSMA/CA

Duplex (uplink/downlink)

OFDM, CSMA/CA

Channel bandwidth

20 MHz

Peak data rate

54 Mbit/s

WLAN IEEE 802.11n*

Frequency range

2400 MHz to 2483.5 MHz

Modulation

BPSK, QPSK, 16QAM, 64QAM

Multiple access

OFDM, CSMA/CA

Duplex (uplink/downlink)

OFDM, CSMA/CA

Channel bandwidth

20 MHz or 40 MHz

Peak data rate

>600 Mbit/s

Bluetooth®

Frequency range

2400 MHz to 2483.5 MHz

Modulation

GFSK
Enhanced Data Rate (EDR): GFSK for Header, π/4 DQPSK, 8DPSK for Data

Multiple access

FHSS

Duplex (uplink/downlink)

TDD

Channel bandwidth

1 MHz

Peak data rate

1 Mbit/s
3 Mbit/s (EDR)

UWB MediaFLO (MB-OFDM) ECMA-0388

Frequency range

3.1 GHz to 10.6 GHz

Modulation

QPSK

Multiple access

TFI-OFDM

Duplex (uplink/downlink)

TDD

Channel bandwidth

528 MHz

Peak data rate

typical:
480 Mbit/s

ZigBee IEEE 802.15.4

Frequency range

2.4 GHz to 2.4835 GHz (World)

902 MHz to 928 MHz (North America)

868.3 MHz (Europe)

Modulation

BPSK (868/915 MHz), OQPSK (MSK) (2.4 GHz)

Multiple access

CSMA/CA

Duplex (uplink/downlink)

TDD

Channel bandwidth

5 MHz

Peak data rate

20 kbit/s (868 MHz)
40 kbit/s (915 MHz)
250 kbit/s (2.4 GHz)

RFID, NFC ISO 14443 (NFC), ISO 15693, ISO 18000 (EPC)

Frequency range

0 MHz to 30 MHz
125 kHz to 164 kHz
6.7 MHz
7.4 MHz to 8.8 MHz
13.56 MHz
27 MHz
125 MHz
433 MHz
868 MHz to 928 MHz
2.45 GHz
5.8 GHz
24.125 GHz

Modulation

FSK, ASK, PSK, PJM, BPSK dependent on standard

Multiple access

TDD, TDM

Duplex (uplink/downlink)

TDD, TDM

Channel bandwidth

typical:
200 kHz / 500 kHz

Peak data rate

848 kbit/s

DECT

Frequency range

Bands (in MHz)
1880 to 1990 (World)
902 to 928 (North America)
2400 to 2483.5 (North America)

Modulation

GFSK

Multiple access

FDMA / TDMA

Duplex (uplink/downlink)

TDD

Channel bandwidth

1.728 MHz

Peak data rate

1 Mbit/s

MOBILE BROADCAST

DVB-H

Frequency range

Dependent on RRC 2006
Germany:
VHF: 174 MHz to 230 MHz
UHF: 470 MHz to 862 MHz
L Band: 1452 MHz to 1492 MHz

Modulation

QPSK, 16QAM
COFDM, (64QAM)

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

TDM

Channel bandwidth

5 MHz, 6 MHz, 7 MHz, 8 MHz

Peak data rate

typical 200 kbit/s max. 384 kbit/s per video service

T-DMB DAB

Frequency range

170 MHz to 240 MHz Band III
2 VHF, Channels 8 and 12
SBS: 208.736 MHz
KBS: 207.008 MHz
VHF L Band:
1452 MHz to 1492 MHz

Modulation

DQPSK, COFDM

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

TDM

Channel bandwidth

1.536 MHz (x3 = 6 MHz)

Peak data rate

0.2 Mbit/s to 0.384 Mbit/s

ISDB-T ISDB-T 1Seg

Frequency range

470 MHz to 862 MHz
558 MHz to 566 MHz
Channel 32 (VHF)

Modulation

DQPSK, QPSK, 16QAM, 64QAM COFDM (13 segments)

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

TDM

Channel bandwidth

6 MHz, 7 MHz, 8 MHz (5.57 MHz)

Peak data rate

0.28 Mbit/s to 1.787 Mbit/s per segment, 13 segments in total

MediaFLO™

Frequency range

698 MHz to 746 MHz

Modulation

QPSK, 16QAM or 4096 OFDM subcarriers

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

TDM

Channel bandwidth

5 MHz, 6 MHz, 7 MHz, 8 MHz

Peak data rate

2.8 Mbit/s to 11.2 Mbit/s in a 6 MHz channel

NAVIGATION

GPS

Frequency range

L1: 1575.42 MHz
L2: 1227.6 MHz

Modulation

BPSK

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

TDM

Channel bandwidth

20.46 MHz

Peak data rate

50 bit/s

Galileo

Frequency range

E5a: 1176.45 MHz
E5b: 1207.14 MHz
E6: 1278.75 MHz
L1: 1575.42 MHz

Modulation

BOC

Multiple access

TDMA / CDMA

Duplex (uplink/downlink)

TDM

Channel bandwidth

E5a: 24 MHz
E5b: 24 MHz
E6: 40 MHz
L1: 32.736 MHz

Peak data rate

E5a: 50 sps
E5b: 250 sps
E6: 1000 sps
L1: 250 sps

Glossary: *3GPP = 3rd Generation Partnership Project; ASK = Amplitude Shift Keying; BOC = Binary Offset Carrier; BPSK = Binary PSK; CCK = Complementary Code Keying; CDMA = Code Division Multiple Access; COFDM = Coded OFDM; CSMA/CS = Carrier Sense Multiple Access with Collision Avoidance; DAB = Digital Audio Broadcasting; DECT = Digital Enhanced Cordless Telecommunication; DL = Downlink; DQPSK = Differential QPSK; DVB-H = Digital Video Broadcasting – Handheld; EDGE = Enhanced Data Rates for GSM Evolution; EDR = Enhanced Data Rate; FDD = Frequency Division Duplex; FDMA = Frequency Division Multiple Access; FHSS = Frequency Hopping Spread Spectrum; FSK = Frequency Shift Keying; GFSK = Gaussian FSK; GMSK = Gaussian MSK; GPRS = General Packet Radio Service; GPS = Global Positioning System; GSM = Global System for Mobile Communications; HPSK = Hybrid PSK; HSDPA = High Speed Downlink Packet Access; HSUPA = High Speed Uplink Packet Access; IMT = International Mobile Telecommunication; ISDB-T = Integrated Services Digital Broadcasting – Terrestrial; KBS = Korean Broadcasting System; LTE = Long Term Evolution; MB-OFDM = Multiband OFDM; MIMO = Multiple Input Multiple Output; MSK = Minimum Shift Keying; NFC = Near Field Communication; OFDM = Orthogonal Frequency Division Multiplex; OFDMA = Orthogonal Frequency Division Multiple Access; OQPSK = Offset QPSK; PBCC = Packet Binary Convolutional Coding; PDC = Personal Digital Cellular; PJM = Phase Jitter Modulation; PSK = Phase Shift Keying; QAM = Quadrature Amplitude Modulation; QPSK = Quadrature Phase Shift Keying; RFID = Radio Frequency Identification; RRC = Regional Radio Conference; SBS = Seoul Broadcasting System; SC = Single Carrier; SOFDMA = Scalable OFDMA; SPS = Samples Per Second; TD-CDMA = Time Division CDMA; TDD = Time Division Duplex; TDMA = Time Division Multiple Access; T-DMB = Terrestrial Digital Multimedia Broadcasting; TD-SCDMA = Time Division Synchronous CDMA; TETRA = Terrestrial Trunked Radio; TFI-OFDM = Time Frequency Interleaving OFDM; UHF = Ultra High Frequency; UL = Uplink; UMB = Ultra Mobile Broadband; UMTS = Universal Mobile Telecommunications System; UWB = Ultra Wideband; VHF = Very High Frequency; WCDMA = Wideband CDMA; WiMAX = Worldwide Interoperability for Microwave Access; WLAN = Wireless Local Area Network*

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***) Standard not yet final, changes possible**

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