An Overview of Wireless Standards & Technology

Past, Present and Future

By: Mark Hoffman
MSEE
ACETEC, Inc.
President
Agenda

• History of Wireless
• Basic Frequency Usage
• Overview of Types of Networks
• WPAN Technologies – Bluetooth, UWB
• WLAN Technologies – WiFi
• WMAN Technologies – WiMax
• WWAN Technologies – Cellular and Related WWAN
  • Generations
  • 3GPP, 3GPP2
• Summary
Mark Hoffman - Background

- Founded ACETEC in 1995
- Penstock, Now Avnet
- Comstream
  - RF Design Engineer
- McDonnell Douglas Technologies Inc.
  - Microwave Design Engineer
- BSEE, MSEE, University of Wisconsin, 1987
Wireless History

- EM Wireless Communications started with the work of Hertz (1860’s) and Maxwell (1860’s).
- In 1893 Nikola Tesla demonstrated the transmission of information over EM waves.
- In 1898 Guglielmo Marconi demonstrated wireless telegraphy from a boat to the Isle of Wight in the English Channel.
- Tesla was really the first to “invent” the radio but Marconi had better public relations.
- Marconi shared with Karl Ferdinand Braun the 1909 Nobel Prize in Physics for their contributions to the development of wireless telegraphy.
First Systems

• Very first systems were Spark Gap Transmitters with a Tank Circuit operating below 500 KHz. Very Noisy. Rx Antenna with Detector.

• Most Early systems were unidirectional, First Station was KDKA in Pittsburg, PA in 1915, Built by Westinghouse

• Amateur (HAM) radio started in the early 1900’s. ARRL formed by 1914. My call is WB9VSG

• WWI - mostly Morse Code. Human can received -10 dB SNR, HAM’s taken off the air

• By 1930’s many Police had Radio’s in their cars

• 1932 Radio ACT was basically the start of the FCC
First Systems - Continued

- WWII, Korea - Still Morse Code. Some AM and FSK Teletype
- 1946 First VHF mobile system installed in St. Louis, MO
  - used operators and had 6 channels
  - ran out of capacity quickly
- AT&T’s Bell Labs found answer: The Cellular Principal with Hand off’s.
- In 1979 NTT in Japan made the first cellular systems
- AT&T decided not to get into the cellular phone market on the advice of consultants
- Later on AT&T bought McCaw Cellular for over $10 billion
Approximate Frequency Allocation

- **Below 100 MHz**: CB radio, HAM radio, pagers, analog cordless phones, AM radio
- **100-800 MHz**: Mainly for broadcast (TV and FM radio). 700 MHz, MediaFlo and DVB-H Mobile TV
- **400-500 MHz**: Trunking radio and some cellular systems (good coverage with low user density)
- **800-1000 MHz**: Cellular and some emergency communication systems, 915 MHz cordless phones
- **1.8-2.0 GHz**: 2G cellular systems
- **2.4-2.5 GHz**: ISM (Industrial, Scientific, Medical) band, cordless phones, WLAN, WPAN, Bluetooth, WiMax
Approximate Frequency Allocation Continued

- **3.3-3.8 GHz**: Fixed wireless and WiMax, UWB
- **4.8-5.8 GHz**: WLAN, fixed wireless, and WiMax, UWB
- **7/8, 11, 13, 15, 18, 23, 26, 28, 32, 38 GHz**: Pt-Pt microwave back haul
- **11-15 GHz**: Most popular satellite TV service
- **14-14.5 GHz Uplink, 11.7-12.2 GHz Downlink**, Ku band, VSAT
Classification of Wireless Networks

- **WPAN (<10m)** – Wireless Personal Area Networks - UWB, Bluetooth, Zigbee 802.15.4
- **WLAN (<100m)** – Wireless Local Area Networks - WiFi 802.11x
- **WMAN (~1 city)** – Wireless Metropolitan Area Network – WiMax
- **WWAN (>1 city)** – Wireless Wide Area Network – Cellular
Source: WiMedia Alliance
WPAN Technologies - Bluetooth

What it stands for: Nothing – Bluetooth was the internal project name at Ericsson.

What it is: Low power, low cost, short range communication, IEEE 802.15.3

Where: All over the world. Frequency 2.45 GHz

Who: Ericsson and others started the technology

Why: For Wireless headsets, cable free connections, etc. Consumes very little power (~1mw), cell phones consume about 200mw, low cost at about $4-$6

When: Late 1990s but did not take off until around 2003

How it works: Frequency hopping spread spectrum (FHSS)
Other WPAN Technologies

- Zigbee IEEE 802.15.4
  - Uses ISM bands, 868 MHz in Europe, 915 and 2.4 GHz
  - Used for Sensing and M2M (Machine to Machine).
- NFC – Near Field Communication
  - For payment and other close in applications
  - Uses magnetic field induction at ~10cm
- RFID
WPAN Technologies - UWB

What it stands for: Ultra Wide Band, AKA Wireless USB, High-speed USB

What it is: IEEE 802.15.3a, short range, low cost IC wireless radio standard. For distances <15m. Note: Two competing standards are slowing the standard process: WiMedia Alliance vs. UWB Forum.

Where it is used: Worldwide at different frequencies.

Who: Intel, Sony, Microsoft, TI, Motorola, Staccato, PulseLink, General Atomics.

Why it was used: Creates a robust, fast, and low cost WPAN communications system. May replace numerous cables around computers and entertainment centers.

How it works: Extremely wide spread spectrum signal. Uses 3.1-10.6 GHz with max speeds of ~110Mbps (~10M) and 480 Mbps (L2M)
Multi-Protocol Application Ecosystem for UWB
UWB Protocol Relationships

Multiple protocols running over a common platform

Single Radio Platform

WiMedia Common Ultrawideband Radio Platform
### Wired USB vs Wireless USB

<table>
<thead>
<tr>
<th>Physical Medium</th>
<th>Cable</th>
<th>Air</th>
</tr>
</thead>
<tbody>
<tr>
<td>Communication Model</td>
<td>One Host, Multiple Devices</td>
<td>One Host, Multiple Devices</td>
</tr>
<tr>
<td>Topology</td>
<td>Tiered Star</td>
<td>Hub and Spoke</td>
</tr>
<tr>
<td>Number of Devices</td>
<td>127</td>
<td>127</td>
</tr>
<tr>
<td>Max Data Rate</td>
<td>480 Mbps</td>
<td>480 Mbps</td>
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<tr>
<td>Software Protocol</td>
<td>Class Drivers</td>
<td>Class Drivers</td>
</tr>
<tr>
<td>Traffic Protocol</td>
<td>Token, Data, Handshake</td>
<td>Token, Data, Handshake</td>
</tr>
</tbody>
</table>

*Only WiMedia UWB is support by Certified W-USB by the USB-IF*
MultiBand-OFDM

- Number of band groups (BG) = 5
  - BG 1-4 consists of three 528 MHz bands
  - BG 5 consists of two 528 MHz bands
- Band subcarriers
  - 128 tone OFDM
  - Tone width = 4.125MHz
  - Tone modulation = QPSK
- Channels
  - TFI (Time Frequency Interleaving)
  - FFI (Fixed Frequency Interleaving)
- WiMedia PHY Specification v1.1
  - Band Switching within BG #1 (3.168 – 4.752 GHz)
Regulatory Status

**USA**
- **Issued ruling in 2002**
  - Unlicensed allocation
  - 3.1GHz-10.6 GHz
  - Emission level: -41.3dBm/MHz
- **Waiver granted in Mar ’05 for power measurement procedures**

**Europe**
- Decision – Dec’06
  - 4.2GHz-4.8GHz (no DAA until Dec 2010)
  - 6GHz-8.5GHz (no restrictions)
  - In-band Emission level: same as FCC
- **Under consideration**
  - DAA 3.1-4.2GHz Mid’07
  - 9GHz extension Mid’07
- **ECMA adopts WiMedia specs (Dec ’05)**
  - ECMA to liaise with ETSI for UWB specs

**Japan**
- **MIC issued ruling in Aug’06**
  - 3.4-4.8GHz (DAA)
  - 4.2-4.8GHz (no DAA until Dec’08)
  - 7.25-10.25GHz (no restrictions)
  - In-band Emission level: same as FCC
  - Indoor use only

**Australia/New Zealand**
- UWB trial allowed on interim licenses

**Hong Kong/Singapore**
- UWB trials allowed
- Emission levels higher than FCC

**China**
- Working towards regulations in 2007
- WiMedia China chapter opened in Oct’08

**Korea**
- **MIC approved spectrum use in Jul’06, ruling expected in 1H’2007**
  - 3.1-4.8GHz (DAA)
  - 4.2-4.8GHz (no DAA until June’10)
  - 7.2-10.2GHz (no restrictions)
  - Emission level: same as FCC
  - Indoor and outdoor use
WLAN Technology - WiFi

What it stands for: Wireless Fidelity
What it is: IEEE 802.11x for wireless internet access in unlicensed spectrum.
Where it is used: Worldwide.
Who uses it: Many chip manufacturers and equipment makers.
Why it is used: For high-speed internet connection within 100m
When was it used: Started in the late 90s
How it works: 802.11a - 5.2 GHz, 54Mbps (max), OFDM
802.11b/g - 2.4 GHz, 11Mbps/54Mbps (max), DSSS/OFDM
802.11i – Address security flaws 100mw max output power
WMAN Technologies – WiMax 802.16e

What it stands for: Worldwide Interoperability for Microwave Access Standard

What it is: Low cost “Last Mile” and mobile broadband high-speed internet connectivity

Where it is used: Worldwide at various frequencies. Fixed WiMax: 10 GHz-66 GHz, theoretical max speed of 70 Mbps per sector LOS (Line of Sight). Mobile WiMax: 2-11 GHz, theoretical max speed of 63 Mbps DL/28 Mbps UP/sector in a 10 MHz channel with 2x2 MIMO (<5km) NLOS (Non Line of Sight).

Who uses it: Sprint is deploying at 2.5 GHz across the US. Motorola and Samsung are making the hardware. Intel is pushing hard for WiMax as well. Many other suppliers. Clearwire with Craig McCaw.

When: Started around early 2000, first for fixed wireless.

How it works: OFDM/OFDMA orthogonal frequency division multiplexing access.
Wireless Generations

1980
1G
AMPS, NMT
Voice mobility

1990
2G
IS-95
GSM
IS-136 (TDMA)
Added voice and data mobility

2000
3G
CDMA2000
UMTS/CDMA
Added voice capacity and high speed data

2005+
4G
WiMax
FlashOFDM
UMB
LTE
Voice and Very High speed data
Evolution of 3G Wireless Standards

2G
- World
  - GSM (TDMA)
- Japan
  - PDC (TDMA)
- U.S.
  - IS-136 (TDMA)
- U.S. Asia
  - IS-95A (CDMA)

2.5G
- World
  - GPRS
  - EDGE
- Japan
  - iDEN (TDMA)
- U.S.
  - IS-95B (CDMA)

3G
- World
  - UMTS (WCDMA)
- Japan
  - HSDPA
- U.S.
  - 1xRTT (CDMA2000)
- U.S. Asia
  - 1xEV-DO (CDMA2000)
  - 1xEV-DV (CDMA2000)
FDMA-Frequency Division Multiple Access for AMPS

- 12.5 MHz
- 30 KHz
- 416

Signal

Frequency
TDMA-Time Division Multiple Access

- Conversation 1
- Conversation 2
- Conversation 3
- Conversation 1
- Conversation 2
- Conversation 3
- Conversation 1
- Conversation 2
- Conversation 3
CDMA-Code Division Multiple Access

Frequency

1.25 MHz Channels

Conversation 6
Conversation 5
Conversation 4
Conversation 3
Conversation 2
Conversation 1

Signal
Cellular WWAN Technology - AMPS

What it stands for: Advance Mobile Phone System
What it is: First US standard
Why it was used: It was easy to implement and used existing FM technology
Who used it: AT&T and Motorola created the first systems
When it was used: Early 1980s
How does it work: FDMA with analog FM modulation
NMT

What it stand for: Nordic Mobile Telephone

What it is: A Swedish system created by Ericsson AB

Why it was used: It was Sweden’s entrance into cell phones

Who used it: Ericsson AB and other in Nordic countries

When it was used: 1980s

How does it work: Analog system with digital switching
GSM

What it stand for: Global System for Mobile communications

What it is: A second generation phone system in which both signaling and speech channels are Digital call quality

Why it was used: Has higher digital voice quality and more capacity

Who uses it: Ericsson, Nokia, Siemens, Alcatel and others in Europe

When it was used: 1990s

How does it work: TDMA with digital switching
UMTS

What it stands for: Universal Mobile Telecommunication Standard

What it is: European standard that continues GSM under 3GPP.

Where it is used: Worldwide

Who uses it: Major carriers in Europe and Cingular in the US.

How it works: WCDMA, 5 MHz channels (1900 MHz UL/2100 MHz DL in many parts of the world).
HSDPA/HSUPA/HSPA/HSPA+~/LTE

What it stands for: High Speed Downlink Packet Access, High Speed Uplink Access, High Speed Packet Access, Long Term Evolution

What it is: UMTS/WCDMA 3GPP Roadmap

Why it is important: Brings DL rates to 14-42 Mbps peak with 2x2 MIMO. Brings UL rates to 11 Mbps peak. LTE: DL up to 150 Mbps, UL 50 Mbps peak.


How it works: Better maximizes data throughput by using entire channel BW with only data within the channel.
UMTS WCDMA 3GPP Evolution

- **Release 99**
  - 64 Kbps CS
  - 384 Kbps PS
  - GSM Compatible
  - Location Services
  - USIM Based
  - December 1999

- **Release 4**
  - Multimedia Messaging
  - EDGE Radio
  - Improved Location Services
  - TDD Low Chip Rate
  - 2001–2003

- **Release 5**
  - HSPDA
  - IP Transports
  - IMS
  - Wideband AMR
  - 2002–2003

- **Release 6**
  - UMTS WLAN Interworking
  - MiMO
  - HSUPA
  - Multimedia Broadcast and Multicast
  - 2003–2005
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<th>AKA</th>
<th>Region</th>
<th>UL Frequency Tx</th>
<th>DL Frequency Rx</th>
<th>Duplex spacing</th>
<th>&lt;REF lor&gt;</th>
<th>Tx BW</th>
<th>Rx BW</th>
<th>Band Gap</th>
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<tr>
<td>1</td>
<td>I</td>
<td>IMT band</td>
<td>Europe, Japan, China &amp; Korea</td>
<td>1950-1980MHz</td>
<td>2140MHz</td>
<td>190MHz</td>
<td>-106.7dBm</td>
<td>60</td>
<td>60</td>
<td>130</td>
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<td>2</td>
<td>II</td>
<td>PCS1900 band</td>
<td>USA</td>
<td>1880-1910MHz</td>
<td>1960MHz</td>
<td>80MHz</td>
<td>-104.7dBm</td>
<td>60</td>
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<td>20</td>
</tr>
<tr>
<td>3</td>
<td>III</td>
<td>DCS1800 band</td>
<td>Europe, Japan &amp; China</td>
<td>1740-1785MHz</td>
<td>1840MHz</td>
<td>95MHz</td>
<td>-103.7dBm</td>
<td>75</td>
<td>75</td>
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<td>4</td>
<td>IV</td>
<td>AWS 17/21</td>
<td>USA</td>
<td>1730-1755MHz</td>
<td>2130MHz</td>
<td>400MHz</td>
<td>-106.7dBm</td>
<td>45</td>
<td>45</td>
<td>355</td>
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<td>5</td>
<td>V</td>
<td>GSM850 band</td>
<td>USA</td>
<td>836.5-849MHz</td>
<td>869-894MHz</td>
<td>45MHz</td>
<td>-104.7dBm</td>
<td>25</td>
<td>25</td>
<td>20</td>
</tr>
<tr>
<td>6</td>
<td>VI</td>
<td>Japan</td>
<td></td>
<td>830-840MHz</td>
<td>875-885MHz</td>
<td>45MHz</td>
<td>-106.7dBm</td>
<td>10</td>
<td>10</td>
<td>35</td>
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<tr>
<td>7</td>
<td>VII</td>
<td>UMTS2600</td>
<td>Europe</td>
<td>2530-2570MHz</td>
<td>2620-2690MHz</td>
<td>120MHz</td>
<td>104.7dBm</td>
<td>70</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>8</td>
<td>VIII</td>
<td>EGSM900</td>
<td>Europe, Japan &amp; China</td>
<td>880-915MHz</td>
<td>925-960MHz</td>
<td>45MHz</td>
<td>-104.7dBm</td>
<td>35</td>
<td>35</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>IX</td>
<td>UMTS1700</td>
<td>Japan</td>
<td>1749.9-1784.9MHz</td>
<td>1844.9-1879.9MHz</td>
<td>95MHz</td>
<td>-105.7dBm</td>
<td>35</td>
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<td>60</td>
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<tr>
<td>10</td>
<td>X</td>
<td>?</td>
<td>?</td>
<td>1740-1770MHz</td>
<td>2110-2170MHz</td>
<td>60MHz</td>
<td>60</td>
<td>60</td>
<td>340</td>
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<tr>
<td>??</td>
<td>??</td>
<td>JCDMA2000</td>
<td>Japan, (KDDI 20MHz)</td>
<td>1930-1940MHz</td>
<td>2120MHz</td>
<td>190MHz</td>
<td>20</td>
<td>20</td>
<td>170</td>
<td></td>
</tr>
</tbody>
</table>
**Flash OFDM**

What it stands for: Fast Low-latency Access with Seamless Handoff Orthogonal Frequency Division Multiplexing.


Where it is used: US and Europe

Who: Flarion (bought by Qualcomm), Vodafone, T-Mobile, Siemens, Digita, and others are using the technology.

Why it is important: Qualcomm bought Flarion for the technology and patent portfolio for $600 million. OFDMA is the technology of the future. Most new Standards use version of OFDM.

How it works: OFDMA takes advantage of the latest DSP technology to make OFDMA work. Very good for high data rates and multi-path.
CDMA “3GPP2” – 1x EV-DO
Rev 0, A, B/UMB

What it stands for: Code Division Multiple Access, 1x Evolution-Data Only Revision 0, A, B, Ultra Mobile Broadband

What it is: CDMA (3GPP2) high-speed data road map. UMB has potential to get to Forward Link: 280 Mbps peak, Reverse Link: 68 Mbps peak.

Where it is used: USA, Korea, Japan, China, India, and South America, Some in Europe

Why it is used: CDMA high speed road map peak rates given:
CDMA2000 1x, 307Kbps FL, 153 Kbps RL
EVDO Rev 0, 2400 Kbps FL, 153 Kbps RL
EVDO Rev A, 3100 Kbps FL, 1800 Kbps RL
EVDO Rev B, 6.2-73.5 Mbps FL, 3.6-27 Mbps RL

When: 1x 1999, Rev 0 ~2002, Rev A present, Rev B 2010

How it works: Better maximizes data throughput by using entire channel. Uses multi-carrier, 1.25x2 or 3 channels.
**CDMA2000 Terminology**


- **CDMA2000 1X** – 3G technology which offers 2 times increase in voice capacity and provides data speeds up to 625 Kbps on a single (1.25 MHz, or 1X) carrier in new or existing spectrum.

- **CDMA2000 1xEV** – Evolution of CDMA2000 1X. 1xEV-DO (Data-Only) uses a separate 1.25 MHz carrier for data and offers peak data rates of 2.4 Mbps. 1xEV-DV (Data-Voice) integrates voice and data on the same carrier.

- **CDMA2000 3X** – 3G technology which offers voice and data on a 5 MHz carrier (or 3 times [3X] the 1.25 MHz carrier).
### CDMA 1x, Band Classes:

<table>
<thead>
<tr>
<th>Band Class (Sub-class)</th>
<th>System</th>
<th>Mobile transmit frequency band (MHz)</th>
<th>Base station transmit frequency band (MHz)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>North American Cellular</td>
<td>824 - 849</td>
<td>869 – 894</td>
</tr>
<tr>
<td>2</td>
<td>Total Access Communications System</td>
<td>872 - 915</td>
<td>917 – 960</td>
</tr>
<tr>
<td>3</td>
<td>Japan Total Access Communications System (A1)</td>
<td>887 - 889</td>
<td>832 – 834</td>
</tr>
<tr>
<td>3</td>
<td>Japan Total Access Communications System (A3)</td>
<td>893 - 898</td>
<td>838 – 843</td>
</tr>
<tr>
<td>3</td>
<td>Japan Total Access Communications System (A2)</td>
<td>898 - 901</td>
<td>843 – 846</td>
</tr>
<tr>
<td>3</td>
<td>Japan Total Access Communications System (A)</td>
<td>915 - 925</td>
<td>860 – 870</td>
</tr>
<tr>
<td>4</td>
<td>Korean PCS</td>
<td>1750 - 1780</td>
<td>1840 – 1870</td>
</tr>
<tr>
<td>5(0)</td>
<td>Nordic Mobile Telephone 450 (A)</td>
<td>452.500 – 457.475</td>
<td>462.500 – 467.475</td>
</tr>
<tr>
<td>5(1)</td>
<td>Nordic Mobile Telephone 450 (B)</td>
<td>452.000 – 456.475</td>
<td>462.000 – 466.475</td>
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<td>5(2)</td>
<td>Nordic Mobile Telephone 450 (C)</td>
<td>450.000 – 454.800</td>
<td>460.000 – 464.800</td>
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<td>5(3)</td>
<td>Nordic Mobile Telephone 450 (D)</td>
<td>411.675 – 415.850</td>
<td>421.675 – 425.850</td>
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<td>5(4)</td>
<td>Nordic Mobile Telephone 450 (E)</td>
<td>415.500 – 419.975</td>
<td>425.500 – 429.975</td>
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<td>5(5)</td>
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<td>479.000 – 483.480</td>
<td>489.000 – 493.480</td>
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<td>5(6)</td>
<td>Nordic Mobile Telephone 450 (G)</td>
<td>455.230 – 459.990</td>
<td>465.230 – 469.990</td>
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### CDMA 1x, Band Classes (continued):

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<tr>
<th></th>
<th>Description</th>
<th>Frequencies</th>
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<tr>
<td>7</td>
<td>North American 700</td>
<td>776 - 794</td>
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<tr>
<td>8</td>
<td>1800 MHz</td>
<td>1710 - 1785</td>
</tr>
<tr>
<td>9</td>
<td>900 MHz</td>
<td>880 - 915</td>
</tr>
<tr>
<td>10</td>
<td>Secondary 800 MHz Band</td>
<td>806 - 901</td>
</tr>
<tr>
<td>11</td>
<td>400 MHz European PAMR Band</td>
<td>452 - 484</td>
</tr>
<tr>
<td>12</td>
<td>800 MHz PAMR Band</td>
<td>870 - 876</td>
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<tr>
<td>13</td>
<td>2.5 GHz IMT-2000 Extension Band</td>
<td>2500 - 2570</td>
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<tr>
<td>14(A)</td>
<td>US PCS 1.9GHz Band (A)</td>
<td>1850 -1865</td>
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<tr>
<td>14(D)</td>
<td>US PCS 1.9GHz Band (D)</td>
<td>1865-1870</td>
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<td>14(B)</td>
<td>US PCS 1.9GHz Band (B)</td>
<td>1870-1885</td>
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<tr>
<td>14(E)</td>
<td>US PCS 1.9GHz Band (E)</td>
<td>1885-1890</td>
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<tr>
<td>14(F)</td>
<td>US PCS 1.9GHz Band (F)</td>
<td>1890-1895</td>
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<td>14(C)</td>
<td>US PCS 1.9GHz Band (C)</td>
<td>1895-1910</td>
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<td>US PCS 1.9GHz Band (G)</td>
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<td>14(H)</td>
<td>US PCS 1.9GHz Band (H)</td>
<td>1915 - 1920</td>
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<tr>
<td>15</td>
<td>AWS Band</td>
<td>1710 - 1755</td>
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</table>
3GPP

- Stands for 3rd Generation Partnership Project
- Also known as the GSM “European” Partnership Project
- Current organization partners are: ARIB (Japan), ATIS (North America), CCSA (China), ETSI (Europe), TTA (Korea), TTC (Japan)
3GPP2

- Also known as the next generation of CDMA2000.
- 3GPP2 is a collaborative effort between five officially recognized SDOs:
  - ARIB (Japan), CCSA (China), TIA (North America), TTA (Korea), TTC (Japan).
- These SDOs are known as the Project’s Organizational Partners (OPs).
Cellular Standard Roadmaps

1G
- AMPS
  - IS-54
  - IS-136

2G
- IS-95
  - CDMA2000 1x

2.5G
- GSM
  - GPRS
  - EDGE

3G
- UMTS
  - CDMA2000 1XEVDO
  - UMTS
  - WCDMA
Future Cellular Standards Roadmap

UMTS → LTE

CDMA2000 → UMB

Flash OFDM
Other Technologies

Satellite Radio: Code-OFDM
DBS Direct Broadcast Satellite: Ku Band, 8PSK with Coding
MediaFlo: Mobile TV, Channel 55, Qualcomm Technology
DVB-H: Mobile TV, European Standard, Completing with MediaFlo
GlobalStar: Satcom phone, Qualcomm designed and built
Iridium: Satcom phone, Motorola designed and built
Thank you!

◆ Stay tuned…..
◆ New changes happening daily.
◆ Cellular( UMB and LTE) vs. Wimax 802.16e
◆ Feel free to contact me if you have any questions:
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