Spectrum Management
Land Mobile Radios

Edison Juleau
National Telecommunications And Information Agency
Office of Spectrum Management
Spectrum Engineering Analysis Division
202-482-1694
ejuleau@ntia.gov
OVERVIEW

- What is Land Mobile Radio (LMR)
- LMR applications
- LMR spectrum
- LMR technologies
- LMR spectrum management
- LMR challenges/Future of LMR
What is LMR?

- **LMR**: communication tools used by an entity to perform the mission. “PLMRS”

- **“LMR-not”**: communications is the end product. (AT&T, VERIZON, DIGICEL) “CMRS”

**PLMRS**: Private Land Mobile Radio Services

**CMRS**: Commercial Land Mobile Radio Services
What is LMR?

- Terrestrial (Land-based/Mobile)
- Mission critical communications
- Dedicated/proprietary/private customized radio systems
- One-to-many
- Push to talk/no dialing
- Listen-then-Talk
- Licensed spectrum/unencumbered
What is LMR?  

LMR in the past

[Image of two soldiers with LMR equipment]
What is LMR?

LMR now
What is LMR?

- **LMR Applications**
  - Public Safety/Non Public Safety
  - Military
  - Transportation
  - Utilities
  - Security
  - Manufacturing
  - **Emergency Operations**
    - Storms/Earthquake/Tornados ....FEMA
LMR Spectrum

LMR SPECTRUM
LMR Spectrum

- LMR Bands (US)
  - 25-900 MHz (VHF/UHF)
  - 2.6/4.9 GHz and Others - Military
### LMR Spectrum

#### US LMR Bands and Allocations

<table>
<thead>
<tr>
<th>FREQ (MHz)</th>
<th>U.S. Allocations</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-50</td>
<td>Shared</td>
</tr>
<tr>
<td>150.8-162</td>
<td>Non-Government</td>
</tr>
<tr>
<td>162-174</td>
<td>Shared</td>
</tr>
<tr>
<td>406.1-420</td>
<td>U.S. Government</td>
</tr>
<tr>
<td>450-470</td>
<td>Non-Government</td>
</tr>
<tr>
<td>470-512</td>
<td>Non-Government</td>
</tr>
<tr>
<td>800-900</td>
<td>Non-Government</td>
</tr>
</tbody>
</table>
LMR Spectrum

- Properties to consider for LMR
  - Propagation Characteristics
  - Size of Country
  - Range
  - Frequency Re-use
  - Terrain/Vegetation
  - Climate
  - Urbanization
  - Noise Variation over Frequency
LMR Technology

- Conventional
  - Legacy
  - FM/Analog Radios
- Trunked
  - Newer Technology (Digital)
  - FDMA/TDMA Technologies

FDMA: Frequency Division Multiple Access
TDMA: Time Division Multiple Access
LMR Technology

- Conventional/Trunked

- Equipment:
  - Repeater/Base Station
  - Mobile
  - Portable

- Operations:
  - Half Duplex
  - Full Duplex
  - Simplex
LMR Technology

➤ Conventional LMR

LMR Half Duplex Operations
LMR Technology

- Conventional LMR

Dispatch Center

Base Station

F1

F2

LMR Half Duplex Operations
LMR Technology

➢ Conventional LMR

LMR Simplex Operations
LMR Technology

 ➢ Conventional LMR (multiple towers)

* Source: GAO/DHS
LMR Technology

- CONVENTIONAL LMR Operations
  - Simplex operations
    - 25-50 MHz, 150-174 MHz
  - Duplex operations
    - 450-470 MHz
    - 800 MHz
  - Satellite
  - Simulcast
LMR Technology

- Conventional Network

  - Pros
    - Works/Simple/Still in Use!
    - Low cost
    - Multi-Sites
    - Analog

  - Cons
    - Limited Privacy
    - Restricted/Rigid Architecture
    - Dedicated Frequencies
    - Inefficient (spectrally)
LMR Technology

- Trunking LMR

“automation”

Repeater

Base Station

F1

F2

Portables

Mobiles

Central Controller

System Monitoring
Network Management

Master Site
LMR Technology

➢ Trunked Network
Trunked Network

- Mobile and portable radios
- Common Air Interface
- Subscriber data peripheral interface
- Base station or fixed station
- RF SubSystem (RFSS)
- Console Interface
- Inter RF SubSystem Interface (ISSI)
- Fixed Station Interface
- Data Network Interface
- Network Management Interface
- Telephone Interconnect Interface
- Network Management
- Public Switched Telephone Network
- Backhaul
LMR Technology

- Trunked Network

- Pros
  - Scalable
  - Interoperability
  - Higher Capacity
  - Efficiency (spectrum)
  - Security
  - More Services (digital)
  - PSTN (Land Line Connection)

- Cons
  - Costly
  - More Complex
  - Digital
LMR Technology

Trunked vs. Conventional Network
LMR Technology

➢ Trunking Standards

- P25 (APCO)
- TETRA
- TETRAPOL
- DMR
- iDEN

APCO: Association of Public safety Communications Officials
TETRA: TErrestrial Trunked RA dio s
DMR: Digital Mobile Radios
iDEN: integrated Enhanced Digital Network
TETRAPOL: TETRA Police
LMR Technology

➤ P25/TETRA Standards

- Interoperability
- Encryption
- Multi-source vendors
- FDMA /TDMA
- Simulcast
- High Data Speeds (up to 28.8 kbps)
- Applications
Mission

- Available Spectrum
- Technological Advances
- Promote Spectrum Efficiency
- Public Safety
- Long Term Planning for LMR
LMR Spectrum Management

- Functions
  - Allocate LMR Spectrum
  - LMR Band Plans
  - LMR Regulations
    (Standards/Emission masks, interference tools, freq. assignment)
  - Border Coordination
LMR Spectrum Management

- LMR Border Coordination
LMR Spectrum Management

- LMR Spectrum Regulations (US)
  - 47 CFR Part 90
  - NTIA Manual (Chapter 5)
  - NTIA LMR Reports
  - FCC/OET Reports
  - TIA TSB 88
LMR Spectrum Management

- LMR - Computer tools (US)
  - Spectrum XXI
  - ATDI
  - Annex I
  - ITM - Propagation
  - Longley Rice
LMR Spectrum Management

- LMR Regulations - Technical Specifications
  - Frequencies
  - Power
  - Antenna Gain
  - Channel Spacing
  - Range - radius of operations
  - OOB/Spurious emissions
  - Grade of Service (GoS)
  - Safety and health issues
Going Forward

- LMR CHALLENGES
  - Spectrum Congestion
  - Migration to 6.25 kHz voice/data channels!
  - 2.6/4.9 GHz LMR
  - Software Defined Radios
  - Standardization (P25)
  - Satellite services
Going Forward

- LMR continues to be relevant in spectrum management
- More licensed spectrum for LMR
- Final Phase of Trunking STDs (P25/TETRA...etc.)
- US FirstNet
Going Forward

- Nationwide LTE Wireless Network for First Responders (Public Safety)
- 20 MHz (700 MHz Band)
  - “D Block”
    - (758-763 MHz/788-793 MHz)
    - (769-775 MHz)/799-805 MHz)
- 3GPP Architecture
- 4G LTE
- Deployment started (2018)

FirstNet: First Responder Network Authority
Going Forward

- **LMR**
  - Fixed BW Channels/Throughput
  - Pre-Configured Channels (12.5/6.25 kHz)
  - Localized (geographically)
  - Does Not Support Data
Going Forward

LMR

12.5 KHz P25 pipe
- A single mission critical voice stream

FirstNet

10 MHz broadband pipe
- Video
- Internet
- Database downloads
- Multiple mission critical voice streams
- Push-to-Talk (non mission critical voice)
- Text messaging
- RoIP
- Messaging/Text
- Metadata

800 x more bandwidth
Going Forward

FirstNet Devices
Summary

- LMR not going away

- Private/Control
- Immediacy
- Reliability/Availability
- Coverage
- Standardization/interoperable
- Multibillion $$$ Industry !!!
References/Resources/Links

www.fcc.gov
www.tiaonline.org
www.etsi.org
www.npstc.org
www.ntia.doc.gov

NTIA Report 08-451
NTIA Report 05-452
NTIA Report 07-447
NTIA Report 06-440
Thank you

Questions
# LMR Spectrum

<table>
<thead>
<tr>
<th>Non-Federal Public Safety Frequency Band (MHz)</th>
<th>Voice</th>
<th>Narrowband Data</th>
<th>Broadband Data</th>
<th>National Interoperability</th>
<th>Outside Interference</th>
<th>Conventional or Trusted</th>
</tr>
</thead>
<tbody>
<tr>
<td>2–25</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>Conventional</td>
</tr>
<tr>
<td>25–50</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Conventional</td>
</tr>
<tr>
<td>72–76</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Conventional</td>
</tr>
<tr>
<td>150–162(^{236})</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>✓</td>
<td></td>
<td>Both</td>
</tr>
<tr>
<td>220–222</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>Conventional</td>
</tr>
<tr>
<td>450–470</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>Both</td>
</tr>
<tr>
<td>470–512(^{237})</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>Both</td>
</tr>
<tr>
<td>763–775</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>Both</td>
</tr>
<tr>
<td>793–803(^{238})</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Both</td>
</tr>
<tr>
<td>806–821</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>Both</td>
</tr>
<tr>
<td>851–866</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>Both</td>
</tr>
<tr>
<td>821–824</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>Both</td>
</tr>
<tr>
<td>866–869</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
<td>Both</td>
</tr>
<tr>
<td>4940–4990(^{239})</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

*Source: DHS Public Safety Spectrum Needs Plan with addition of broadband notation for 700 MHz bands
# LMR Spectrum Management

LMR Band Plans (406.1-420 MHz)

## Table 1: Paired Channels

<table>
<thead>
<tr>
<th>Channel</th>
<th>Center Frequency</th>
<th>Center Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>406.1125</td>
<td>415.1125</td>
</tr>
<tr>
<td>2</td>
<td>406.1250</td>
<td>415.1250</td>
</tr>
<tr>
<td>3</td>
<td>406.1375</td>
<td>415.1375</td>
</tr>
<tr>
<td>4</td>
<td>406.1500</td>
<td>415.1500</td>
</tr>
<tr>
<td>5</td>
<td>406.1625</td>
<td>415.1625</td>
</tr>
<tr>
<td>6</td>
<td>406.1750</td>
<td>415.1750</td>
</tr>
<tr>
<td>7</td>
<td>406.1875</td>
<td>415.1875</td>
</tr>
<tr>
<td>8</td>
<td>406.2000</td>
<td>415.2000</td>
</tr>
<tr>
<td>9</td>
<td>406.2125</td>
<td>415.2125</td>
</tr>
<tr>
<td>10</td>
<td>406.2250</td>
<td>415.2250</td>
</tr>
<tr>
<td>11</td>
<td>406.2375</td>
<td>415.2375</td>
</tr>
<tr>
<td>12</td>
<td>406.2500</td>
<td>415.2500</td>
</tr>
<tr>
<td>13</td>
<td>406.2625</td>
<td>415.2625</td>
</tr>
<tr>
<td>14</td>
<td>406.2750</td>
<td>415.2750</td>
</tr>
<tr>
<td>15</td>
<td>406.2875</td>
<td>415.2875</td>
</tr>
<tr>
<td>16</td>
<td>406.3000</td>
<td>415.3000</td>
</tr>
<tr>
<td>17</td>
<td>406.3125</td>
<td>415.3125</td>
</tr>
<tr>
<td>18</td>
<td>406.3250</td>
<td>415.3250</td>
</tr>
<tr>
<td>19</td>
<td>406.3375</td>
<td>415.3375</td>
</tr>
<tr>
<td>20</td>
<td>406.3500</td>
<td>415.3500</td>
</tr>
<tr>
<td>21</td>
<td>406.3625</td>
<td>415.3625</td>
</tr>
<tr>
<td>22</td>
<td>406.3750</td>
<td>415.3750</td>
</tr>
<tr>
<td>23</td>
<td>406.3875</td>
<td>415.3875</td>
</tr>
<tr>
<td>24</td>
<td>406.4000</td>
<td>415.4000</td>
</tr>
<tr>
<td>25</td>
<td>406.4125</td>
<td>415.4125</td>
</tr>
<tr>
<td>26</td>
<td>406.4250</td>
<td>415.4250</td>
</tr>
<tr>
<td>27</td>
<td>406.4375</td>
<td>415.4375</td>
</tr>
<tr>
<td>28</td>
<td>406.4500</td>
<td>415.4500</td>
</tr>
</tbody>
</table>
## LMR Spectrum

### Frequency Re-use

<table>
<thead>
<tr>
<th>Frequency (MHz)</th>
<th>30</th>
<th>50</th>
<th>160</th>
<th>450</th>
<th>900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Re-use Distance (km)</td>
<td>225</td>
<td>200</td>
<td>177</td>
<td>160</td>
<td>145</td>
</tr>
</tbody>
</table>

* Based on HAAT/ERP