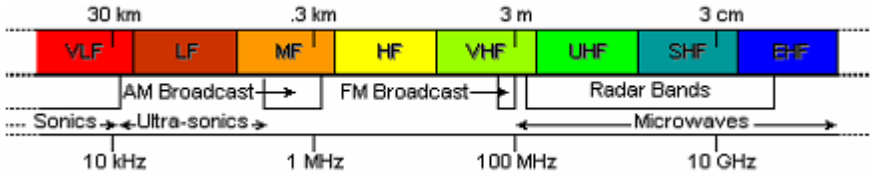


Spectrum Management Land Mobile Radios

Mohammed A. Shamma & Edison Juleau

National Telecommunications And Information Agency

Office of Spectrum Management

Spectrum Engineering Analysis Division

202-482-6325, 202-482-1694

mshamma@ntia.doc.gov, ejuleau@ntia.doc.gov

With additional contributions from Ms. Yang Weng, OSM, SAB div. Chair
yweng@ntia.doc.gov

OVERVIEW

- What is Land Mobile Radio (LMR)
- LMR applications
- Spectrum for LMR
- LMR technologies
- Spectrum management for LMR
- Challenges for LMR
- Future of LMR

What is LMR?

- Private Land Mobile Radio Services (PLMRS)
  - 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?

- PLMRS: communication tools used by an entity to perform the mission.
- CMRS : communications is the end product.

PLMRS: Private Land Mobile Radio Services
CMRS: Commercial Land Mobile Radio Services

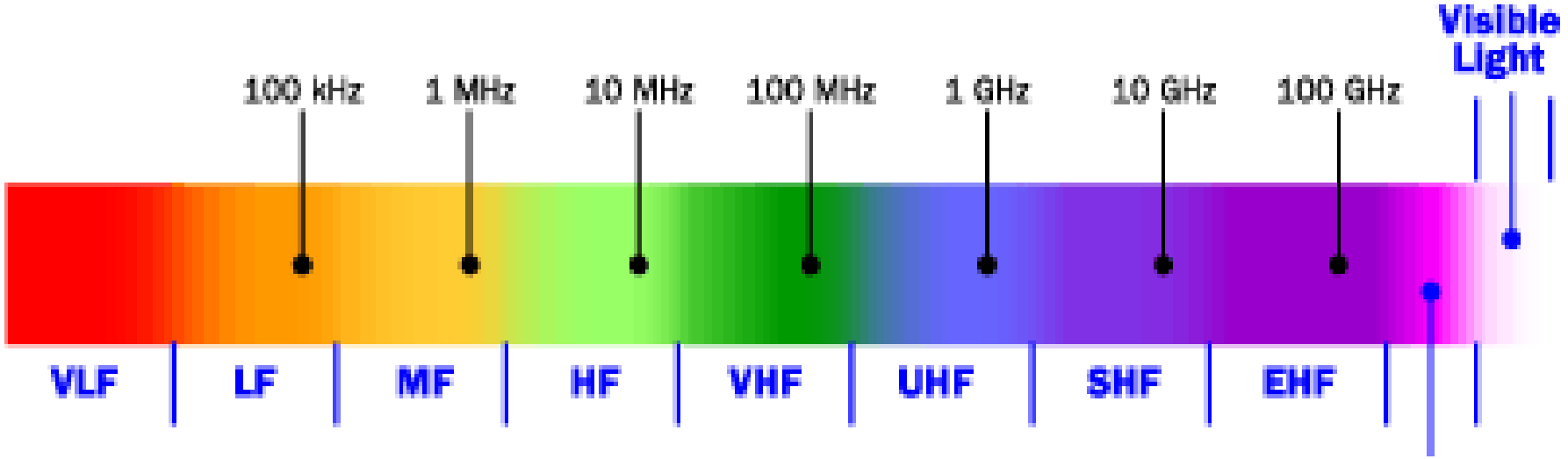
What is LMR ?

The Present

What is LMR?

- LMR Applications
  - Government
    - Public Safety
    - Non Public Safety
    - Military
  - Industry
    - Transportation
    - Utilities
    - Security
    - Manufacturing
  - Emergency Operations
    - Storms/Earthquake/Tornados ….FEMA

LMR Spectrum



LMR SPECTRUM

LMR Spectrum

- PLMRS Bands (US)
  - 25-900 MHz (VHF/UHF)
  - 2.6/4.9 GHz
  - Others (Military)

LMR Spectrum

- US LMR Bands and Allocations

FREQ (MHz)	U.S. Allocations
30-50	Shared
150.8-162	Non-Government
162-174	Shared
406.1-420	U.S. Government
450-470	Non-Government
470-512	Non-Government
800-900	Non-Government

LMR Spectrum

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

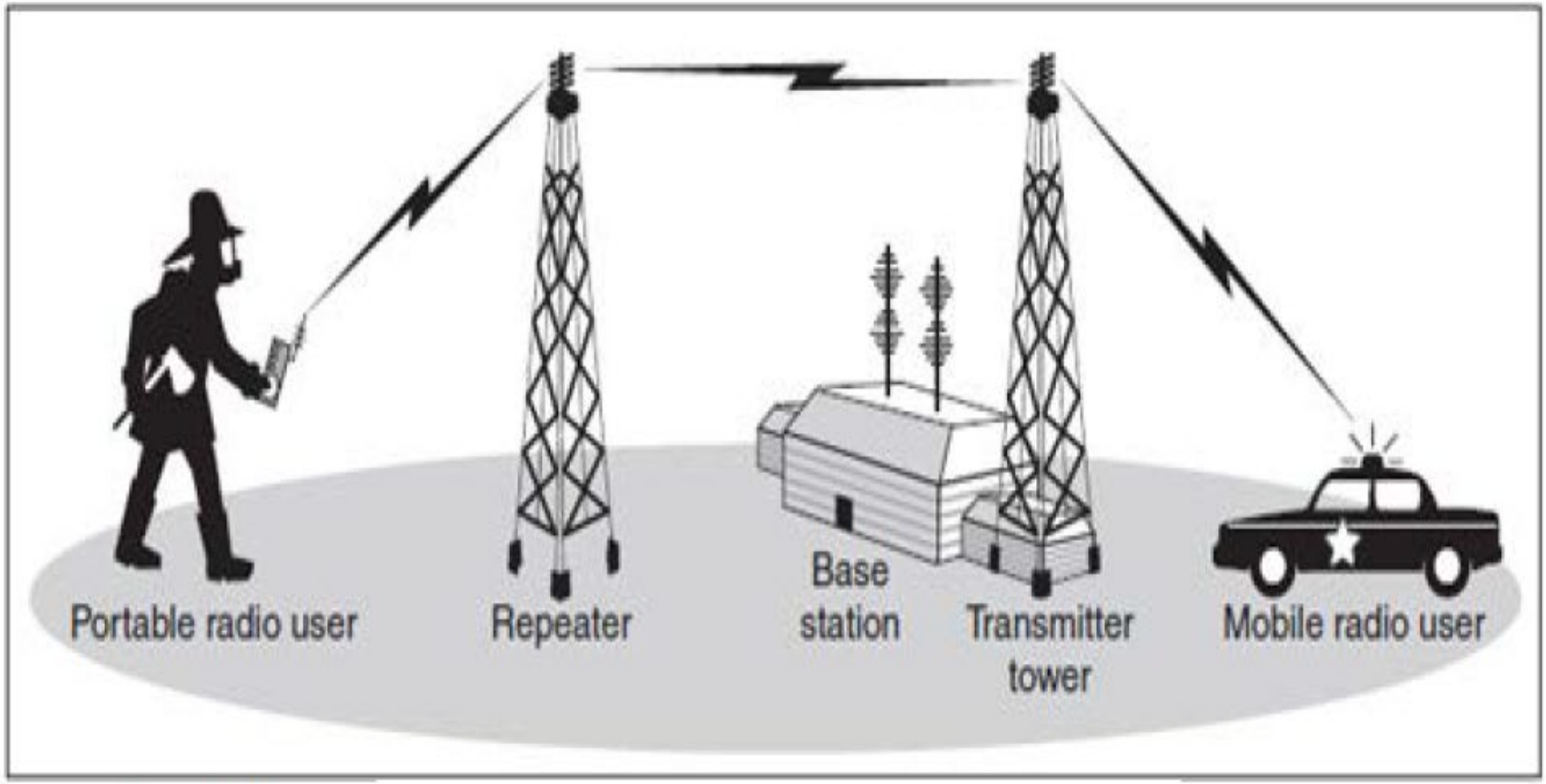
LMR Technology

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

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

LMR Technology

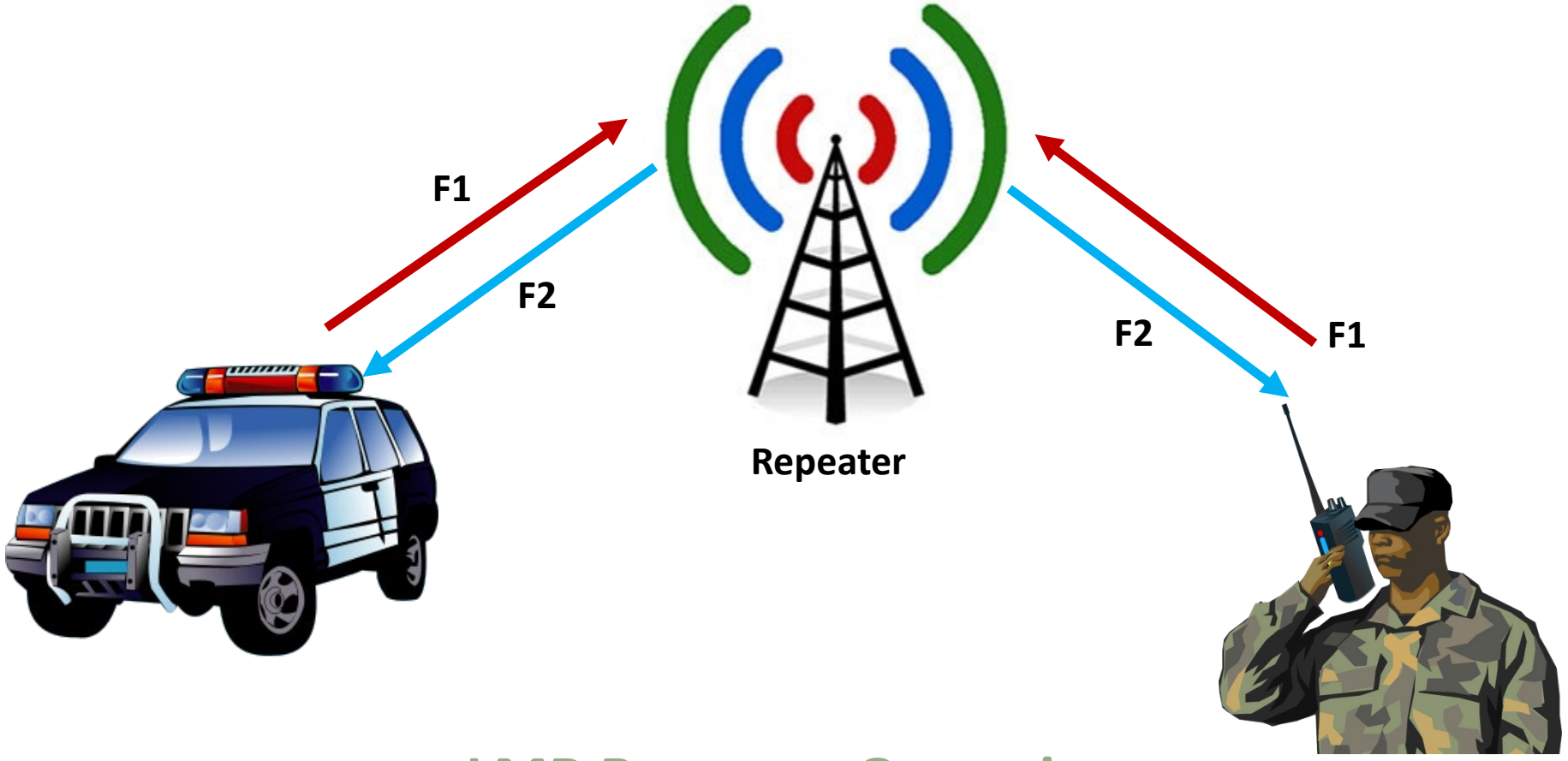
➢ The Basics



* Source: GAO/DHS

LMR Technology

➢ The Basics

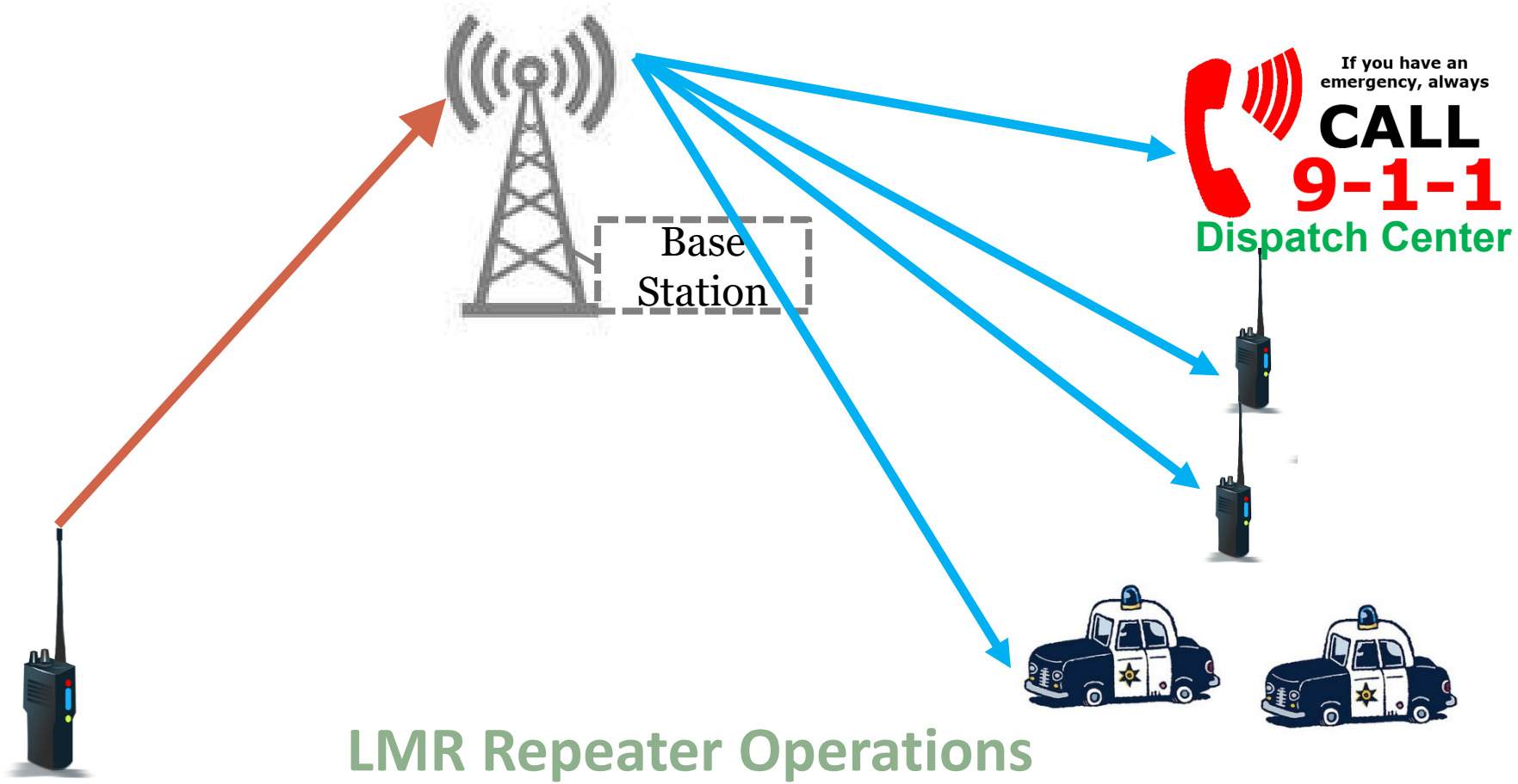


LMR Repeater Operations

* Based on HAAT/ERP

LMR Technology

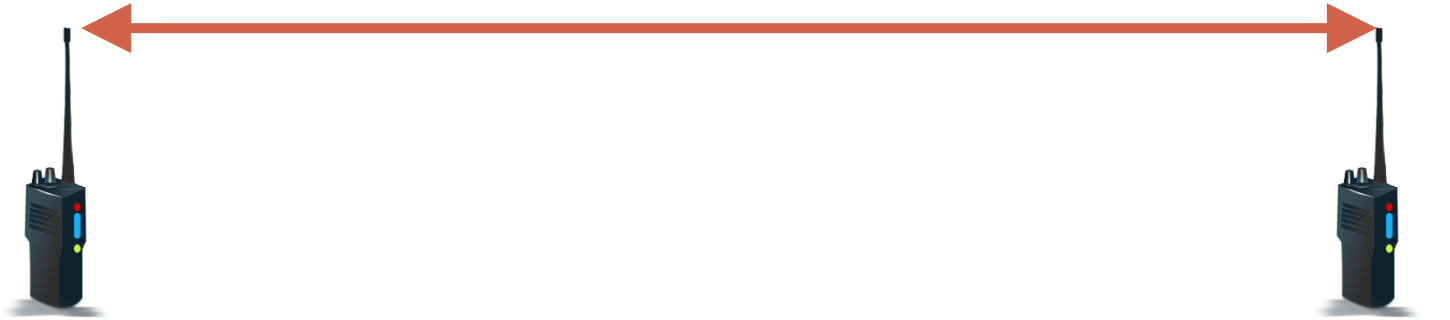
- Conventional LMR



LMR Repeater Operations

LMR Technology

- The Basics



Single-Frequency Operations

* Based on HAAT/ERP

LMR Technology

➢ CONVENTIONAL LMR Operations

- Simplex (Single channel, one way)
  - 25-50 MHz, 150-174 MHz
- Half Duplex (1- channel, two ways)
  - 450-470 MHz
- Full Duplex (2-channel, two ways)
  - 800 MHz
- Satellite
- Simulcast

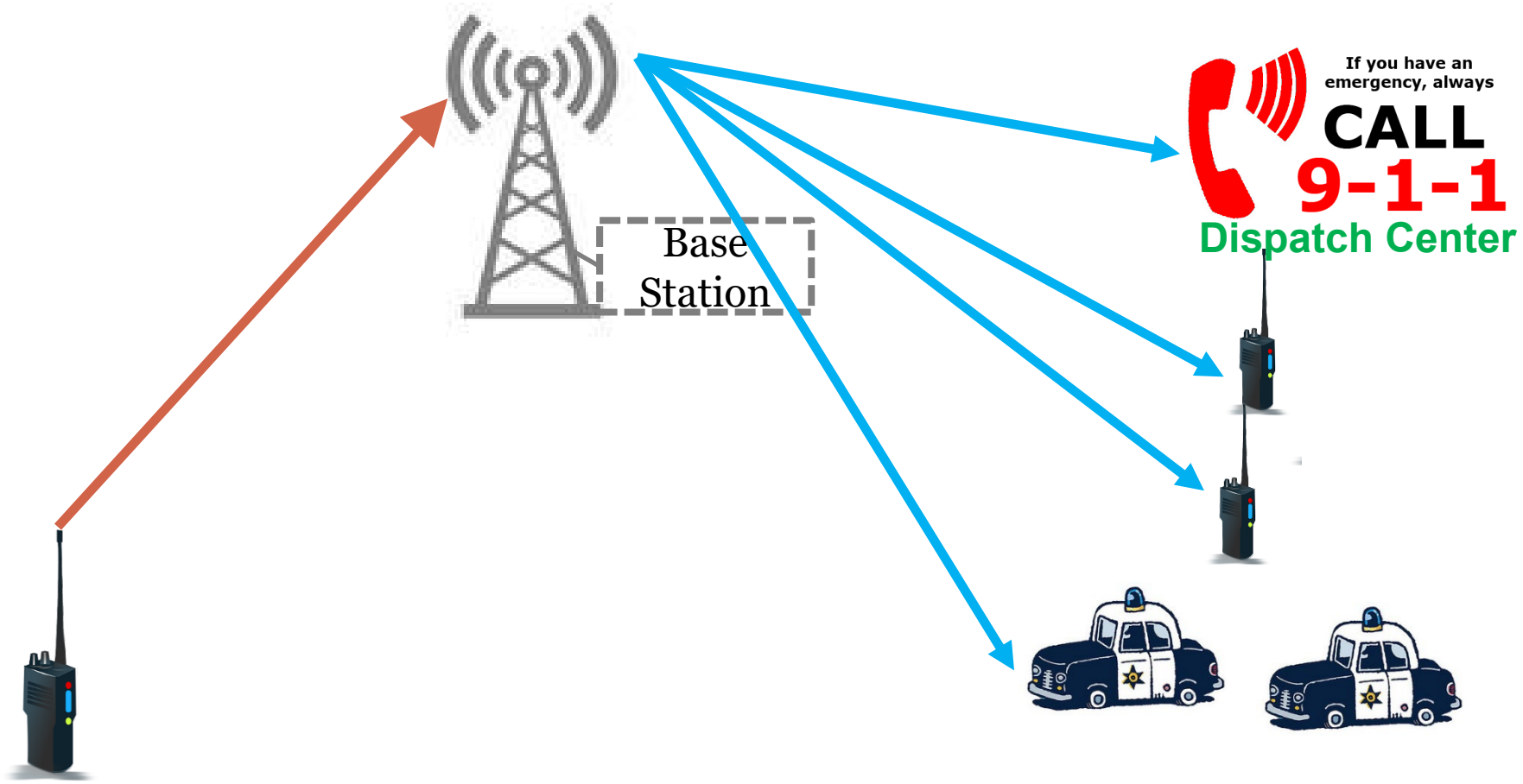
LMR Technology

- Conventional Network

  - Analog/FM Radios
  - Limited Privacy
  - Restricted/Rigid Architecture
  - Dedicated Frequencies
  - Inefficient (spectrally)
  - Multi-Site (to extend range)
  - Works/Simple/Still in Use!
  - Low cost

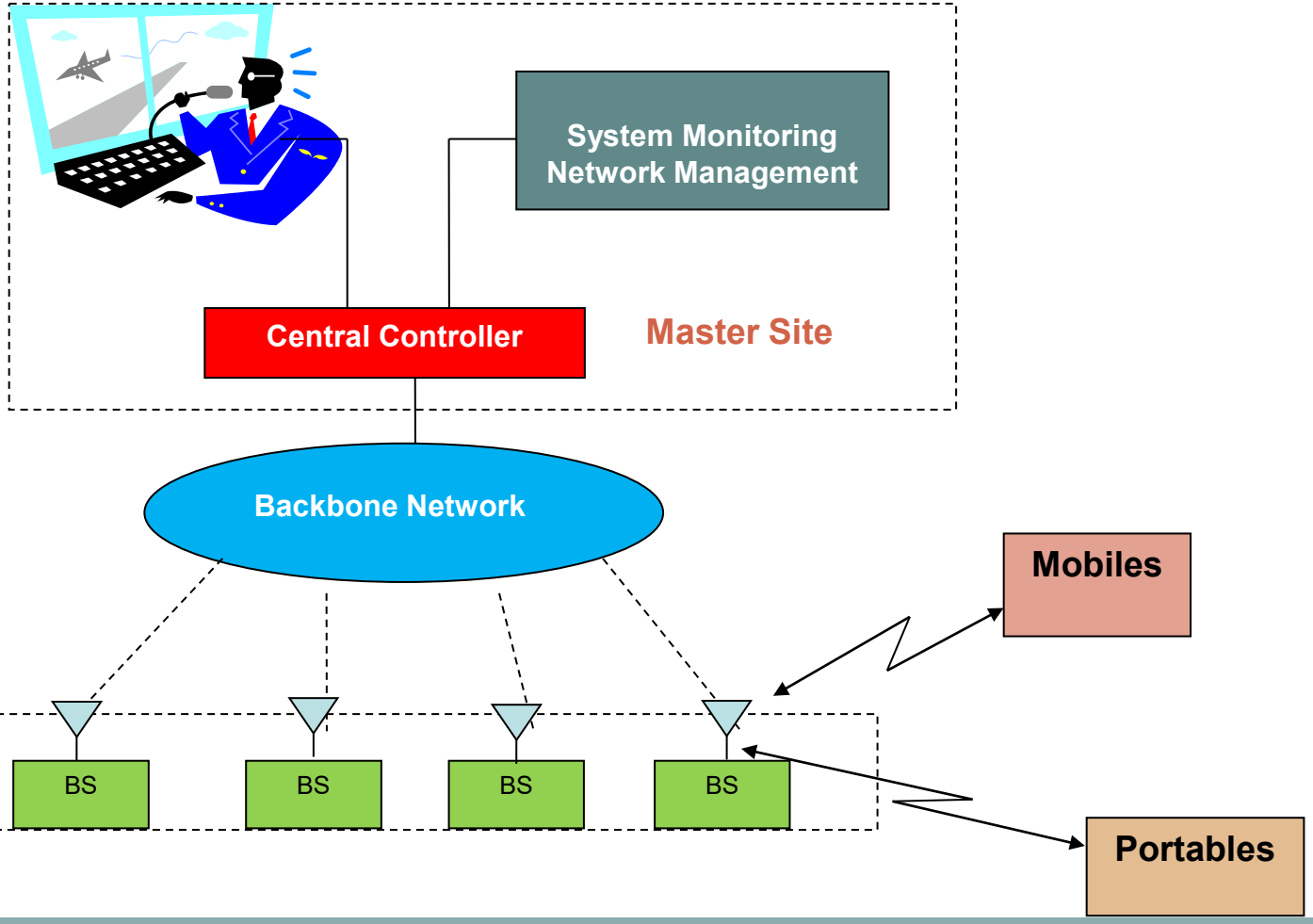
LMR Technology

- Trunking Network

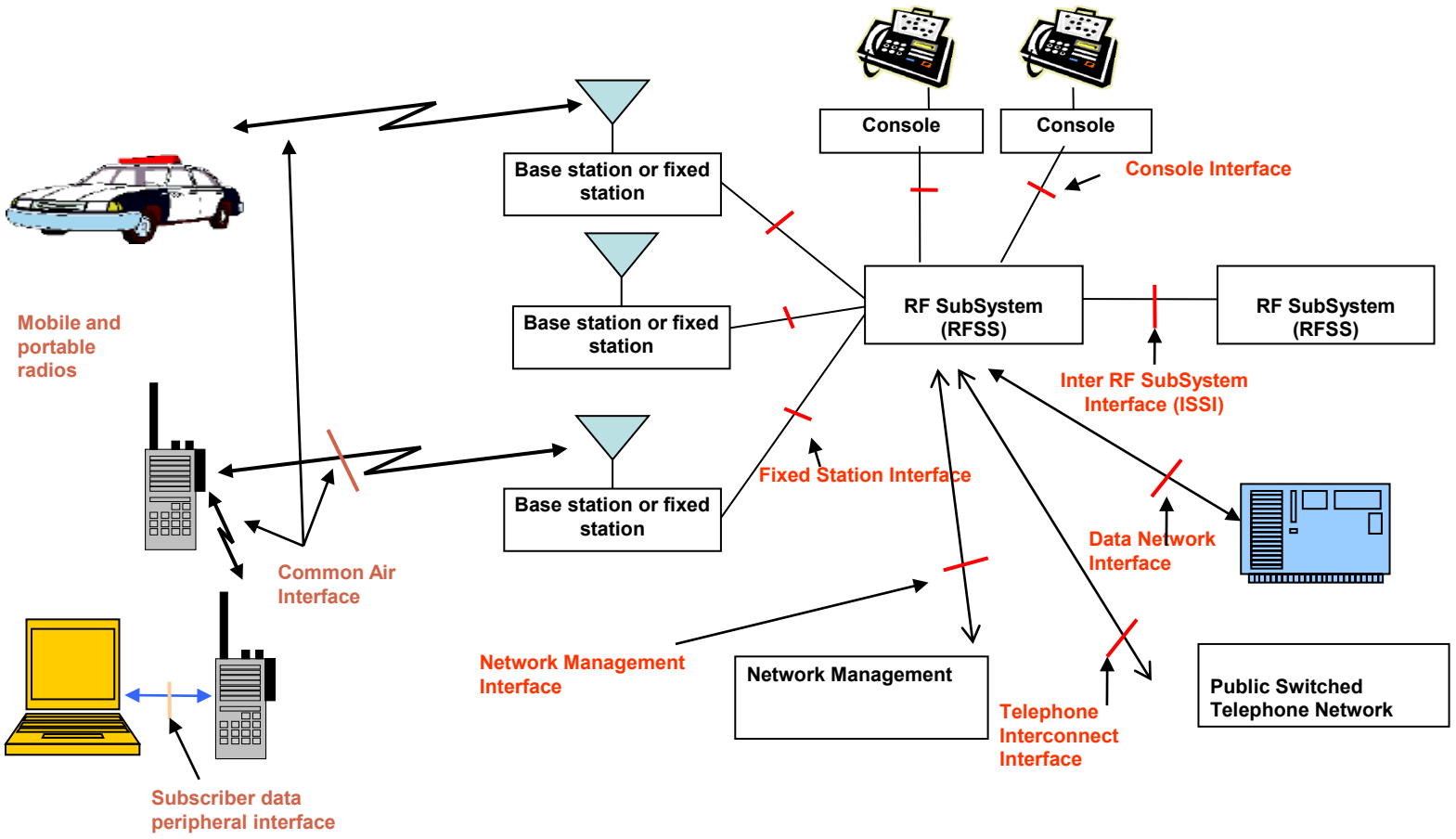


LMR Technology

Trunked Network



LMR Technology



Trunked Network

LMR Technology

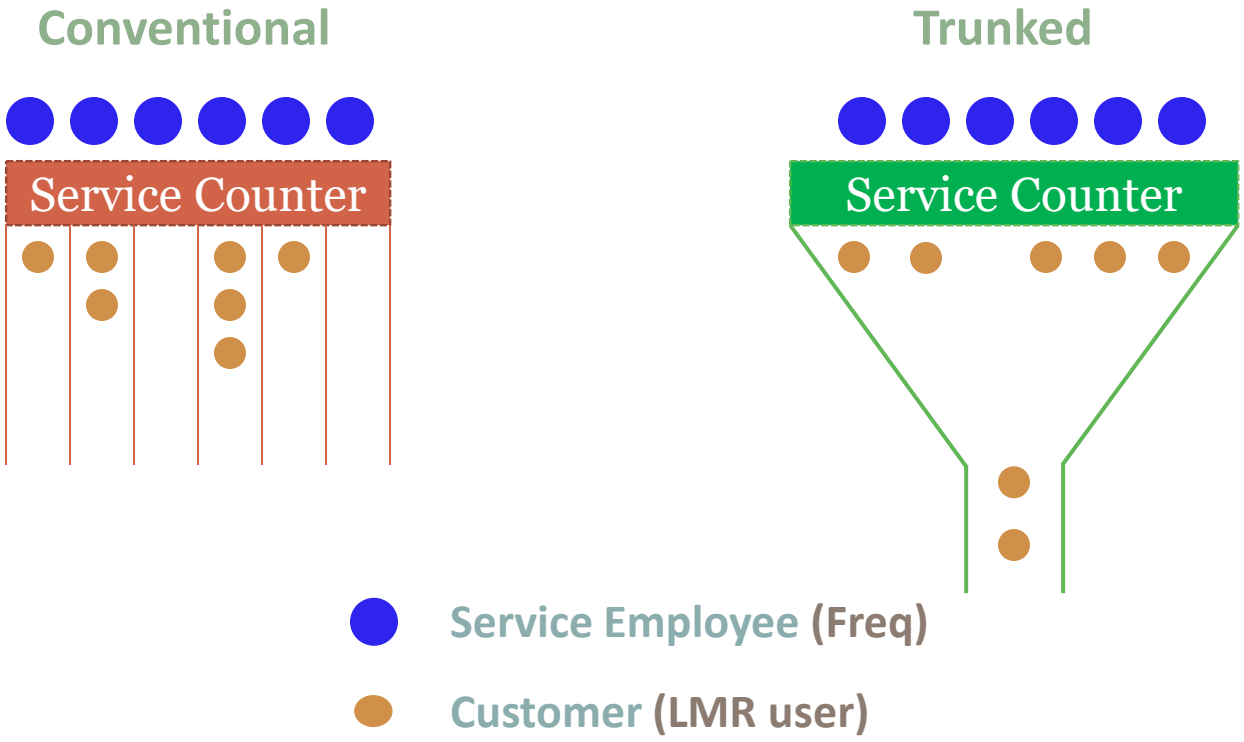
➢ Trunked Network

- ❑ Computerized Switch
- ❑ Digital Signaling
- ❑ More Services (Caller ID/short messages…etc.)
- ❑ More Secured
- ❑ Land Line Connection (PSTN)
- ❑ Flexible/Customizable/Scalable
- ❑ Pool of Frequencies
- ❑ Spectrum Efficient

LMR Technology

- Trunked Network
  - Digital Modulation
  - Smooth Migration (Analog/Digital Modes-)
  - Scalable
  - Higher capacity
  - Interoperability
  - Simulcast
  - Cost more

LMR Technology



Trunked vs. Conventional Network

LMR Technology

- **Trunked Standards**
  - P25 (APCO)
  - TETRA
  - TETRAPOL
  - DMR
  - iDEN

APCO: Association of Public safety Communications Officials
TETRA: TErrestrial Trunked RAdios
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

LMR Spectrum Management

- **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 Spectrum Regulations

- ❑ 47 CFR Part 90
- ❑ NTIA Manual (Chapter 5)
- ❑ NTIA LMR Reports
- ❑ FCC/OET Reports
- ❑ ETSI Reports
- ❑ ITU-R Studies
- ❑ TIA TSB 88

LMR Spectrum Management

- LMR Spectrum Regulations- Computer tools
  - 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
  - Safety and health issues

LMR Spectrum Management

- LMR Border Coordination

Going Forward

- LMR CHALLENGES
  - Spectrum Congestion
  - Migration to 6.25 kHz voice/data channels!
  - 2.6/4.9 GHz LMR
  - Software Defined Radios
  - Standardization
  - 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.)
- 6.25 kHz channels
- Technological Advances (CMRS,PCS)
- 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 begins 2018

FirstNet: First Responder Network Authority

Going Forward

- LMR

- Fixed BW Channels/Throughput
- Pre-Configured Channels
- Localized
- Does Not Support Data

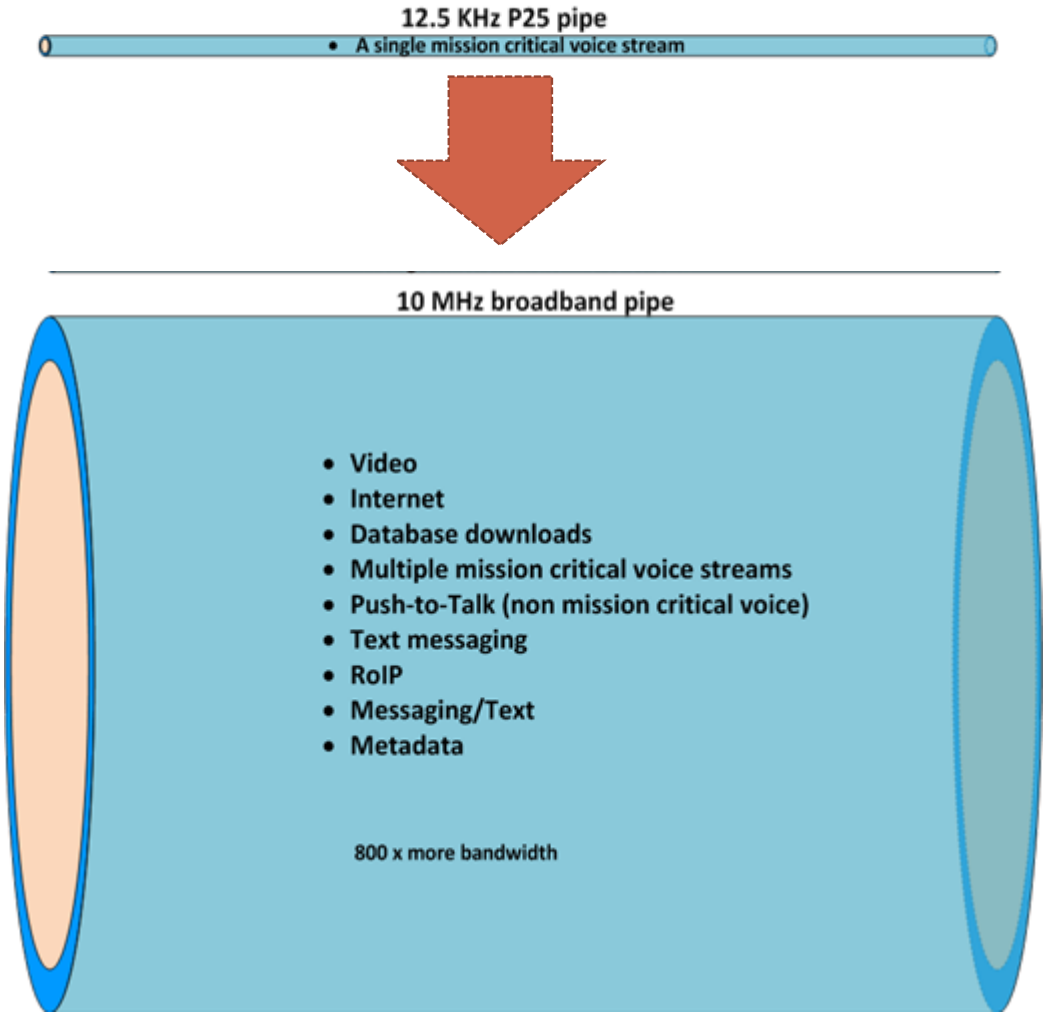
12.5 KHz P25 pipe

- A single mission critical voice stream

Going Forward

Firstnet Devices

Going Forward



FIRSTNET

Summary

- LMR not going away
  - Private/Control
  - Immediacy*
  - Reliability/Availability*
  - Coverage
  - Standardization/interoperable
  - $$$$$
  - PLMRS and CMRS
- Likely the future is a multi mode LMR/FirstNet scenario*
  - Multi mode systems accommodate LMR and FirstNet within single device
  - Likely this will be the future scenario for the foreseeable time frame**

*(especially in direct unit to unit communications where standard FirstNet units may not have as much power as current LMR units and delays or lack of communication is a major factor… p.s. imagine scenario of two fire fighters in proximity needing to coordinate together in the early moments of a disaster…relying on a connection that must travel through an entire network is likely not a good option, and having lower power units is also not favorable)

** Look at for example L3Harris units L3 Harris XL-200M Multiband Mobile Radio (firstnet.com)

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

EXTRA SLIDES

LMR Spectrum

Non-Federal Public Safety Frequency Band (MHz)	Voice	Narrowband Data		Broadband Data	National Interoperability[235]	Outside Interference	Conventional or Trunked
2–25	✓	✓					Conventional
25–50	✓	✓					Conventional
72–76	✓	✓					Conventional
150–162[236]	✓	✓			✓		Both
220–222	✓	✓			✓		Conventional
450–470	✓	✓			✓		Both
470–512[237]	✓	✓					Both
763–775 793–805[238]	✓	✓		✓	✓		Both
806–821 851–866	✓	✓				✓	Both
821–824 866–869	✓	✓			✓	✓	Both
4940–4990[239]	✓			✓			N/A

*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		
Channel	Center Frequency	Center Frequency
1	406.1125	415.1125
2	406.1250	415.125
3	406.1375	415.1375
4	406.150	415.150
5	406.1625	415.1625
6	406.175	415.175
7	406.1875	415.1875
8	406.200	415.200
9	406.2125	415.2125
10	406.225	415.225
11	406.2375	415.2375
12	406.250	415.250
13	406.2625	415.2625
14	406.275	415.275
15	406.2875	415.2875
16	406.300	415.300
17	406.3125	415.3125
18	406.325	415.325
19	406.3375	415.3375
20	406.350	415.350
21	406.3625	415.3625
22	406.375	415.375
23	406.3875	415.3875
24	406.400	415.400
25	406.4125	415.4125
26	406.425	415.425
27	406.4375	415.4375
28	406.450	415.450

Table 1: Paired Channels		
Channel	Center Frequency	Center Frequency
47	406.6875	415.6875
48	406.700	415.700
49	406.7125	415.7125
50	406.725	415.725
51	406.7375	415.7375
52	406.750	415.750
53	406.7625	415.7625
54	406.775	415.775
55	406.7875	415.7875
56	406.800	415.800
57	406.8125	415.8125
58	406.825	415.825
59	406.8375	415.8375
60	406.850	415.850
61	406.8625	415.8625
62	406.875	415.875
63	406.8875	415.8875
64	406.900	415.900
65	406.9125	415.9125
66	406.925	415.925
67	406.9375	415.9375
68	406.950	415.950
69	406.9625	415.9625
70	406.975	415.975
71	406.9875	415.9875
72	407.000	416.000
73	407.0125	416.0125
74	407.025	416.025

Table 1: Paired Channels		
Channel	Center Frequency	Center Frequency
93	407.2625	416.2625
94	407.275	416.275
95	407.2875	416.2875
96	407.300	416.300
97	407.3125	416.3125
98	407.325	416.325
99	407.3375	416.3375
100	407.350	416.350
101	407.3625	416.3625
102	407.375	416.375
103	407.3875	416.3875
104	407.400	416.400
105	407.4125	416.4125
106	407.425	416.425
107	407.4375	416.4375
108	407.450	416.450
109	407.4625	416.4625
110	407.475	416.475
111	407.4875	416.4875
112	407.500	416.500
113	407.5125	416.5125
114	407.525	416.525
115	407.5375	416.5375
116	407.550	416.550
117	407.5625	416.5625
118	407.575	416.575
119	407.5875	416.5875
120	407.600	416.600

LMR Spectrum

- Frequency Re-use

Frequency (MHz)	30	50	160	450	900
Re-use Distance (km)	225	200	177	160	145

* Based on HAAT/ERP