Defining Multi-Band Radio Requirements

A Procurement Guide for Emergency Responders

December 2012

Homeland Security

Science and Technology

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EXECUTIVE SUMMARY

The Department of Homeland Security (DHS) Science and Technology Directorate would like to thank all of the local, state, and federal agencies that participated in the Multi-Band Radio (MBR) pilot project, and especially the lead pilot agencies. Many public safety agencies were involved in providing the initial requirements necessary for the development of the MBR and provided valuable input throughout the pilot. Without those dedicated public servants, the MBR project would not have been so successful. In addition, manufacturers came to the table with their own resources to make this a true public-private research and development effort. In today's economy, manufacturers are cautious about investing in new and emerging technologies that may or may not provide a return on their investment. Without the investment of all parties involved, the MBR would not have come to fruition as a viable alternative to achieve interoperability for public safety as quickly as it has. If the capabilities provided by the MBR can be credited for saving just one life, then the entire project has been a success.

The MBR was not considered a candidate to replace all hand-held, portable radios in use by public safety and others primarily due to cost, even though high-end, fully-featured single band radios cost about the same (as the MBR). The vision was that the MBR would be a tool used at the supervisory level, incident commander level, and by emergency managers.

The MBR provides a capability to communicate with agencies during any event requiring mutual aid or support. It is also considered a prime candidate for cache radios (i.e., radios that are pre-programmed with nationally-recognized and authorized interoperability channels, held in reserve at specific locations for use during major events). Cache radios allow agencies the flexibility to travel outside their jurisdictions and provide a communications capability during mutual aid support. The case can be made that if the MBR provided similar performance as a single band radio and was priced at the same price point, the MBR would be considered the radio of choice.

This guide was written to assist departments and agencies in making MBR radio equipment procurement decisions. The guides includes two parts. The first part provides background information to users responsible for writing the operational requirements and for the financial managers, providing them a better understanding of the regulatory requirements and the problems with radio communications interoperability between responders. The second part of the guide consists of a series of appendices that provide greater technical detail on the capabilities of the MBR and accessories available from the original manufacturers and from secondary markets. Each provides background information on the specific capability or feature and contains a checklist that will allow the user to conduct research of available products by manufacturer. The appendices include batteries, battery chargers, external speaker microphones, holsters and a host of other specialty accessories developed for specific applications.

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APPENDIX

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1.0 INTRODUCTION

For years, interoperable communications between public safety agencies were often limited to an officer from one agency relaying mission critical information through a dispatcher-to-dispatcher information exchange to another officer. This was the only available means to share information.

Some agencies relied on sharing radios if sufficient equipment was available, though often it was not. Others were fortunate to have radio channels that could be programmed into other agency radios to provide direct interoperability. In extreme cases some agencies relied on the use of radio scanners to monitor another agency's radio traffic, but this was not reliable.

With the expansion of cellular technologies, some agencies relied on cell phones to contact other agencies directly or to contact officers in the field. This was problematic and compromised safety because cellular communications were limited to a one-to-one communications path rather than the one-to-many communications path that land mobile radio (LMR) can provide. Dispatchers and other responders were not aware of what was going on as communications were limited. A true LMR solution was required.

Today, with the availability of MBR technologies, the need for alternative interoperability solutions has been greatly reduced. The MBR offers the user community a single tool to bridge the radio communications gap that once existed; however, it takes more than a radio to bridge the interoperability gap. Proprietary features used by some manufacturers in trunking systems have created a stranglehold on procurements, nearly eliminating open competition.

The MBR project encouraged manufacturers to build MBR equipment to the Project 25 (P-25) open suite of standards as a way to avoid the dominance of proprietary trunking systems and educating users of the value of open standards. Compliance with these standards should open the marketplace to open competition, ensure an even playing field, reduce equipment costs, and foster interoperable communications.

1.1 DEFINING THE MULTI BAND RADIO

A multi-band radio provides the user community with a single, portable LMR capable of operating on multiple radio bands. The MBR can also be defined as a software defined radio (SDR). SDR technologies replaced hardware components, such as filters, amplifiers with digital signal processing, and analog-to-digital converters through the use of software, that were contained within a radio.

The MBR entered the technology field due to the lack of a single radio capable of operating on all radio bands in use by emergency responders. The definition of "multi" means two or more, or two or more radio bands in this case. In actuality, only two *primary* radio bands are being used by responders today since the radio spectrum is broken up into multiple groups called bands.[1]

[1] http://www.ntia.doc.gov/files/ntia/publications/spectrum_wall_chart_aug2011.pdf

The Very High Frequency (VHF) band extends from 30-300 MHz and the Ultra High Frequency (UHF) band extends from 300-3000 MHz so you can see that there are technically two distinct bands. Some manufacturers offer full spectrum radios that can operate on all bands, while others offer radios capable of operating on all bands *with exceptions*. One such exception is the 380-512 MHz radio bands. Not all equipment is capable of operating across the entire range.

The VHF Low Band, a radio band still in use today by many agencies, is located in the 30 to 40 MHz band. This band will continue to be used by agencies well into the future. Due to unstable propagation characteristics, such as the susceptibility for long range skip where the signal can travel long distances, the use of this band has diminished. The limited availability of VHF low band equipment from manufacturers has resulted in numerous agencies migrating to other bands where sufficient spectrum is available.

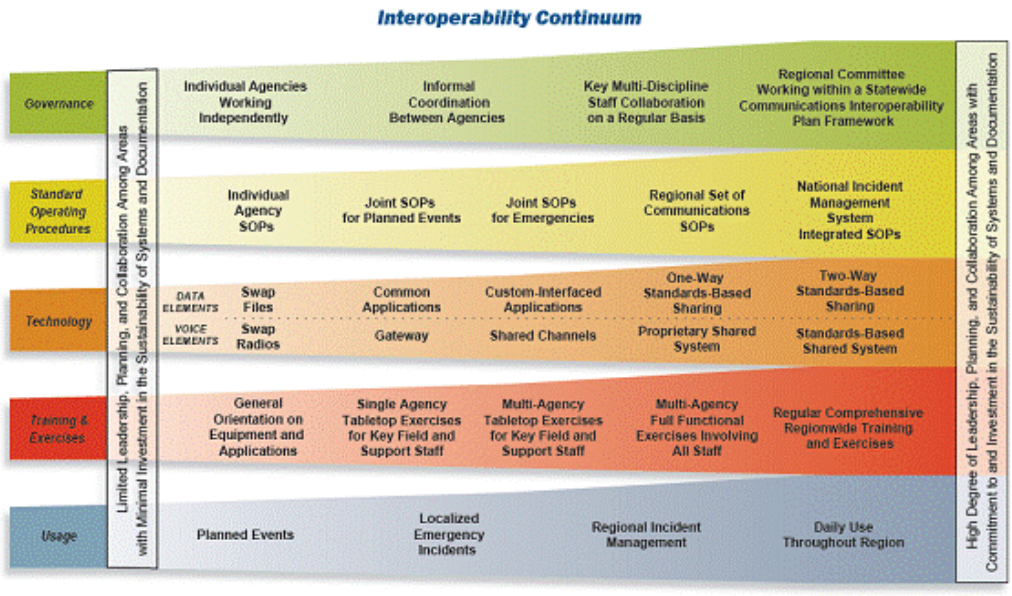
1.2 INTEROPERABILITY CONTINUUM

Achieving true interoperability is a challenge and involves more than just technology. The DHS Interoperability Continuum[2] was written in a preliminary attempt to resolve interoperability challenges. The Continuum identifies five elements necessary to achieve successful interoperability. These include governance, standard operating procedures, technology, training and exercises, and usage. For example, if effective governance cannot be achieved, the remaining four elements have no value.

The lack of available MBR technology presented a major challenge since no single radio provided coverage of all radio bands in use by public safety. Solutions were rudimentary: swapping of radios, if an agency had sufficient equipment to loan; the use of gateways (often expensive to buy and maintain, activate, or deploy); sharing channels (if agencies shared the same radio band, had sufficient channels available, and did not rely on that shared channel for their network); proprietary shared systems (highlighting the use of proprietary trunking systems that required outside agencies to purchase proprietary equipment); and, standards-based shared systems (focusing on an open standard or a P-25 trunking system). This is just a sampling of what is necessary to achieve interoperable voice communications.

The MBR was not considered the "solution of solutions," but offers more functionality than what previously existed. The graphic below shows the breakdown of radio bands that are in use today by public safety, the Department of Defense, and federal government agencies.

[2] http://www.safecomprogram.gov/SiteCollectionDocuments/Interoperability_Continuum_Brochure_2.pdf



DHS SAFECOM INTEROPERABILITY CONTINUUM

LAND MOBILE RADIO BANDS IN USE BY PUBLIC SAFETY, THE DEPARTMENT OF DEFENSE AND FEDERAL AGENCIES

	138–144 MHz	150–174 MHz	162–174 MHz	380–400 MHz	406–420 MHz	450–470 MHz	470–512 MHz	700 MHz	800 MHz
Public Safety Agencies		✦				✦	✦	✦	✦
Department of Defense (DoD)	✦			✦					
Federal Agencies (non-DoD)			✦		✦				
Multi-Band Radio	✦	✦	✦	✦	✦	✦	✦	✦	✦

Primary Land Mobile Radio Bands in Use by Public Safety, DoD, and Federal Agencies.

The DoD primarily operates in two LMR radio bands: the 138-144 MHz band and the 380-400 MHz band

The federal government operates in two LMR bands: the 162-174 MHz band and the 406.1-420 MHz band

State and local governments operate in the 150-174, 450-512, and 700/800 MHz LMR bands

1.3 SPECTRUM REGULATION

Spectrum is regulated within the Unites States by two separate bodies: the Federal Communications Commission (FCC) and the National Telecommunications and Information Administration (NTIA). There are distinct differences between the two and the United States is the only country in the world with two spectrum regulatory bodies. Since spectrum is an international resource to every country, the Department of State (DoS) plays a key role in negotiations with our neighbors, Canada and Mexico. Spectrum regulation that involves both Canada and Mexico requires close negotiations that result in spectrum-sharing treaties signed by all governments.

The FCC

Public safety agencies are ***licensed*** by the FCC and operate in multiple radio bands. These public safety bands are located on specific segments of spectrum between 150 MHz and 870 MHz. The bands are the 150-174 MHz, 450-470 MHz, 470-512 MHz (identified for auction)[3], and the 700 and 800 MHz bands. Information about agencies holding licenses in these bands can be found on the FCC Universal Licensing System (ULS) database.[4]

The NTIA

Federal agencies do not receive licenses from the FCC, but receive ***allocations and authorizations*** from the NTIA[5] under the Department of Commerce. DoD has the largest number of allocations and authorizations in the 138-144 MHz and 380-400 MHz bands. Federal agencies have allocations and authorizations in the 162-174 MHz and 406.1-420 MHz bands. Information about these allocations and authorizations are maintained in the Government Master File (GMF).[6] Access to the GMF is limited and not generally available to the public.

1.4 SPECTRUM EFFICIENCY

Spectrum *efficiency* is defined as the effective use of available radio spectrum. Spectrum is a finite resource and cannot be replaced or reproduced. In 1993 the NTIA published the NTIA Report 93-300 "Land Mobile Spectrum Efficiency – A Plan for Federal Government Agencies to Use More Spectrum-Efficient Technologies,"[7] which identified key findings and made recommendations on efforts that would make use of spectrum as efficiently as economic and mission requirements permit. The report highlights the migration from wideband 25 kHz voice channels to narrowband 12.5 kHz channels, which would in effect nearly double the number of channels available. The report also highlights that under certain conditions, trunking systems were more efficient than conventional systems. Larger agencies with significant numbers of users often have high volume/short duration messages that would be better served with a

[3] http://www.govtrack.us/congress/bills/112/hr3630
[4] http://wireless.fcc.gov/uls/index.htm?job=home
[5] http://www.ntia.doc.gov/
[6] http://www.ntia.doc.gov/category/spectrum-management
[7] www.its.bldrdoc.gov/publications/2326.aspx

trunking system. Trunking systems became popular at the regional and statewide level due to their efficiency factor and the ability to allow roaming across the systems.

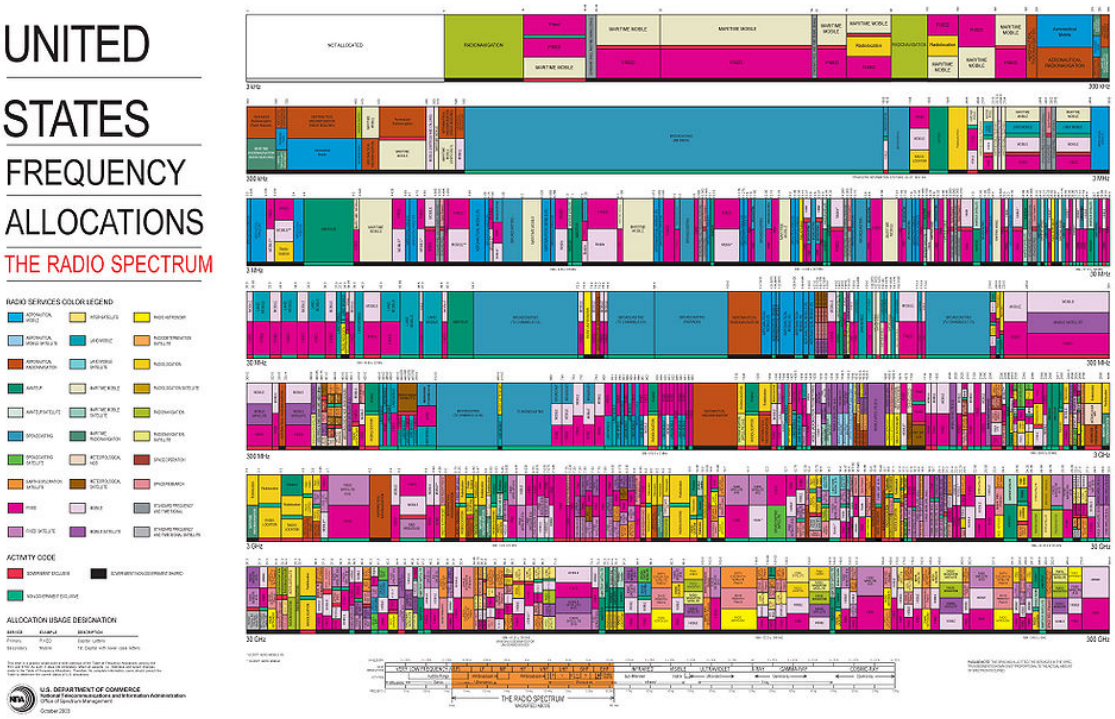
For most agencies, a conventional system will meet their needs and cost less than trunked systems. Conventional systems rely on the use of base station repeaters for long distance communications. Users that are in range of each other can use the repeater output channel and talk directly to each other. These systems require dedicated channels assigned to a group or division within the organization such as fire/rescue, emergency medical services (EMS), or law enforcement.

Larger agencies generally operate on trunked systems that are more spectrum efficient than conventional systems. Trunking systems do not assign any specific channel or frequency to any group, but share the channels on an as-needed-basis. When a channel is required, a control channel assigns a channel pair to the requesting user; once communications are complete, the channel returns to the control channel for reassignment. Trunked systems may also be of value to small agencies joining into regional networks and sharing infrastructure costs. Many states offer access to statewide trunking networks.

1.5 NARROWBANDING

The FCC and the NTIA recommended a migration from wideband radio channels to narrowband channels to reduce congestion and free up spectrum for other uses. Narrowbanding consists of migrating wideband systems using 25 kHz channels to be narrowbanded to 12.5 kHz channels on spectrum below 512 MHz. The NTIA mandated a migration plan for federal systems to have all systems migrated to narrowband systems by January 1, 2005 for VHF and January 1, 2008 for UHF systems. Many federal government agencies have met the narrowband mandate, but others have not. The FCC mandated a migration plan for narrowbanding non-federal agencies that is set for January 1, 2013 and will not likely be met by all wideband users.

The general assumption is that if you reduce (narrow) the width or size of a wide radio channel by half, the available spectrum could be doubled. This may appear to be true, but in reality, narrower channels may offer a solution for voice radio only while creating a problem with other modes, such as broadband voice and data and streaming video, where a wider channel is needed. Emerging technologies include plans to migrate voice radio communications onto broadband networks and share infrastructure for voice, data, and video applications which require a larger bandwidth.



NTIA Frequency Allocations Chart

2.0 REQUIREMENTS

The ability to communicate has been identified as the most important mission critical technology needed today. Equipment requirements are identified at the user level to ensure that the technology meets their day-to-day operational needs. Professional or commercial-grade radio equipment is required to survive in the environment first responders are exposed to on a daily basis. Sometimes known as public safety-grade equipment, this radio equipment is built to specific mission critical standards to survive in the rugged environment in which first responders operate, including the extreme cold of winter, the extreme heat of firefighting (both structural and wild land fires), and exposure to water that firefighters face daily.

Dependability is also critical to ensure the safety and protection of responders. For this reason, most manufacturers build equipment to meet military specifications (MilSpec). MilSpec often refers to a series of specifications known as the 810 series that evaluates equipment against exposure to harsh elements, heat/cold, dust/dirt, water/mud, and dropping -- the same conditions in which the military operates. The MilSpec standard has been adopted by many manufacturers to ensure equipment meets the rigid procurement requirements of first responders. These requirements and more are covered in the appendices.

The general requirements identified for the MBR project were basic and consisted of the following:

- Operate in the 138-174, 380-512 MHz, public safety, federal, and DoD bands
- Operate in the 700/800MHz public safety bands
- FCC Type Accepted, class A radio performance in all bands
- Dimensions and weight comparable to single band radio
- Transmit power output 0.5-5.0 watts
- Analog-digital conventional systems
- Digital/trunked P-25 systems
- Sufficient channel capacity to meet user needs
- Standard and optional battery types
- Encryption capability; OFB-DES, AES
- Over-the-Air-Rekey (OTAR) FIPS 140-2
- Intrinsic safe certification
- Meet Military Standard 810 test procedures
- Sufficient audio output for noisy environments
- Global Positioning System/location capable
- Clone capable
- Programmable front and side buttons
- Noise cancelling microphones, both internal and external

3.0 PROCUREMENT

There are many ways to search for information about products. New products often generate user groups that share experience using specific products with other users. This resource provides value for others considering the procurement of similar equipment. Detailed information can often be found using internet search engines to identify how others rate a particular product and reference good features, bad features, missing features, etc. Manufacturers maintain websites that provide details on their product lines and most provide equipment specifications sheets. It should be noted that equipment specifications as advertised or posted are based on the *typical performance* of that product and performance may vary.

If you anticipate a large procurement, you should consider purchasing or requesting manufacturers to loan equipment to conduct your own in-house test and evaluation if you will be using your legacy radio system. Many vendors will provide demonstration equipment to allow agencies to conduct evaluations and may also provide you with programming assistance to ensure their equipment operates on your system. If you are procuring a complete system replacement, you will have to rely on others for comparison. Remember to check how long any particular product has been on the market since many manufacturers discontinue product lines after 10 years of production. You don't want to purchase a new system only to find out after a year that it's going out of production and spare parts and repairs are unavailable.

3.1 Product Research:

Basic product research likely begins with searching the internet. The internet opened the market and made researching new products or technologies easier. Procurements begin with basic requirements identified by the users - law enforcement, fire/rescue, EMS, and emergency managers.

3.2 Product Reviews:

These are an excellent resource because they include input obtained from product owners. Product reviews are generally written by a mix of non-technical and technical users.

3.3 User Groups:

Again the internet provides another excellent resource through user groups. User groups are often formed by product owners to share information on a particular product. You will find detailed information on how the product performs, what limitations have been identified, and other details. Participation in user groups is free and can help you build a case for buying or avoiding products that other users have identified as not meeting similar requirements.

3.4 Test Demonstrations:

Some manufacturers offer equipment on a loan basis, which provides an excellent opportunity to test equipment on your agency's network at little or no cost. From a marketing standpoint, this demonstrates that manufacturers are confident that their product will meet your requirements. By them making equipment available at no cost to users, they give you the opportunity to conduct an internal evaluation on how the equipment works and obtain feedback from users in their work environment. This allows for a great pass/fail evaluation. Manufacturers or their representatives may offer to visit your agency and assist in programming equipment to operate on your system, unless such practices are prohibited within your organization. This is another opportunity to evaluate a technology or product.

3.5 Request for Information (RFI):

Another avenue for obtaining information is to publish a Request for Information (RFI) or send RFIs to various manufacturers or vendors. An RFI is not a commitment to purchase, but rather a way of obtaining information about a specific product or product with specific capabilities. The RFI process is common in the federal government as a non-commitment means of obtaining information.

The most critical first step for first responders is to identify technical requirements through a requirements-gathering process and sufficient funding for the procurement. Agencies will search for equipment meeting their requirements and best value. In today's challenging economic situation, many agencies are finding it difficult to maintain their existing legacy systems since some equipment is no longer supported or repaired by the original manufacturer. Some agencies rely on purchasing used equipment in order to maintain legacy operations. Many agencies have decided to merge with regional or state systems or have built new systems that incorporate all disciplines and have expanded them to include public works or utilities, school districts, and other divisions within their local government. Equipment used by non-public safety divisions may not require public safety-grade radio equipment which can cost twice as much as non-public safety grade equipment. Equipment with fewer features may support their missions. Public safety-grade equipment may include encryption and intrinsic safe certification. These capabilities increase the cost and may not be required; therefore, a mix of equipment may be more appropriate.

4.0 CAPABILITIES

A true MBR should be capable of operating across the primary radio band used today, the 136-870 MHz band. The 380-520 MHz band is often broken down into low-split or high-split by manufacturers that offer dual band radios that can only accommodate two of the three recognized bands. Agencies with a requirement to communicate with DoD facilities may require radios capable of operating in the 380-400 MHz band. Agencies with a requirement to communicate with other federal agencies may require a radio capable of operating in the 406.1-420 MHz band; numerous federal agencies operate trunking systems in this band.

RADIO BANDS

Frequency Bands and Operating Range

VHF (No-Split)
VHF no-split radios operate in 136 – 174 MHz (MBR)
VHF (Low-Split)
VHF low-split radios operate in 136 – 150.8 MHz
VHF (High-Split)
VHF high-split radios operate in 150.8 – 174 MHz

UHF (No-Split)
UHF no-split radios operate in 380 – 512 (520) MHz (MBR)
UHF (Low-Split)
UHF low-split radios operate in 406.1 – 420 MHz
UHF (High-Split)
UHF high-split radios operate in 450 – 512 MHz

700 MHz
700 MHz 763 – 775 MHz and 793 – 805 MHz
800 MHz
800 MHz radios 806 – 824 MHz and 851 – 870 (869) MHz

MBR features and performance are the two most critical elements in the identification of a suitable radio.

Operating Mode/Emission Designator/Multi-Mode Operation
Analog Mode
Analog FM radios are built to the EIA/TIA-603 standard
Analog Conventional 11K0F3E/16K0F3E
Digital Mode
Digital radios are built to the EIA/TIA-102 standard

5.0 PERFORMANCE

The capabilities and performance of the radio in both transmit and receive mode are the most critical elements in the identification of a suitable radio. MBRs are transceivers -- capable of transmitting and receiving signals in multiple radio bands. Receiver and transmitter performance should be included as part of the procurement process. DHS manages the Project 25 Compliance Assessment Program (P-25 CAP) and maintains a list of equipment from multiple manufacturers that complies with the P-25 standard. Independent laboratories evaluate equipment and if found in compliance with the P-25 standards lists it on the Responder Knowledge Base (RKB) website at www.rkb.us. Agencies purchasing equipment using federal grant funds should ensure the equipment complies with the P-25 standards and are listed on the RKB website.

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5.1 Receiver Performance; Key concerns/criticality

- ***Receiver Sensitivity*** **-** a sensitive receiver can extract a weak signal that may originate at a long distance from the receiver. Receiver sensitivity is the ability of a receiver to bring in weak signals.
- ***Adjacent Channel Rejection*** **-** critical to public safety; the receiver must have the ability to reject strong signals from channels adjacent to or in close proximity to those in use.
- ***Intermodulation Rejection*** **-** internal to the receiver; the ability to reject interference within the receiver.
- ***Overload Rejection*** **-** the ability to reject strong signals from interfering with receiver, often called receiver overload.

5.2 Transmitter Performance; Key concerns/criticality

Wireless devices, such as radio transmitters, require authorizations or certifications before they can be marketed within the United States. The FCC has regulatory authority over all wireless devices, licensed and unlicensed, brought into the United States. The majority of devices used by emergency responders fall under Chapter 47 of the Code of Federal Regulations (47 CFR). Manufacturers have their wireless devices tested by accredited laboratories that measure performance and submit a Declaration of Conformity that verifies that the device meets the technical requirements. These tests include:

- Radio Frequency (RF) Output Power
- Modulation Characteristics
- Bandwidth
- Spurious Emissions
- Field Strength
- Frequency Stability
- RF Radiation Exposure

6.0 STANDARDS

MBR equipment is built to multiple standards developed by standards development organizations consisting of users, engineering organizations, and manufacturers. These standards include P-25, intrinsic safety standards, and encryption standards, to name a few.

6.1 P-25 Standards

P-25 is a suite of standards under development for the design and manufacturing of digital interoperable radio equipment for users at the local, state, and federal level supported by the Telecommunications Industry Association (TIA)[8] TR-8 engineering committee. The standards focus on first responder requirements and have been adopted in other countries. One goal of P-25 was to develop an open standard, allowing all manufacturers to create a competitive and interoperable environment. Another goal was to ensure spectral efficiency by migrating from wideband 25 kHz channels to more efficient 12.5 kHz channels. P-25 was established in 1989 by the Association of Public Safety Communications Officials (APCO), the National Association of State Technology Directors (NASTD), and the U.S. Government.

Telecommunications Industry Association (TIA): Is the lead in the development and publication of the P-25 standards. The TIA is accredited by the American National Standards Institute (ANSI) to develop *voluntary, consensus-based industry standards using input from stakeholders that include manufacturers and the user community*. Within the TIA, the TR-8 Engineering Committee follows the TIA-102 series of standards in support of the development process of the P-25 suite of standards.

Participants on the TR-8 Committee[9] include members from industry and local, state, and federal government agencies, all actively involved in the development of the P-25 standards. The TR-8 committee is responsible for resolving technical guidelines, as well as defining the interoperability, compatibility, and compliance requirements to meet the DHS P-25 Compliance Assessment Program CAP.

There are two phases of in the development of the P-25 standards: Phase I identifies the migration from 25 kHz channels to 12.5 kHz FDMA Common Air Interface channels and Phase II identifies the future migration to 6.25 kHz TDMA Common Air Interface channels in the future for the more effective and efficient use of spectrum. With the emerging Broadband over Long Term Evolution (BB/LTE) technologies, it is believed that Phase II may not be necessary.

6.2 Encryption Standards

Encryption standards are identified in the Federal Information Processing Standard (FIPS) documents for Advanced Encryption Standard (AES) TIA/EIA-102. P-25 uses 256 bit encryption, and 128 bit encryption for TIA/EIA-102 Data Encryption Standard (DES), or OFB-DES mode. Both are recognized encryption, OFB-DES and AES encryption consists of a group

[8] http://www.tiaonline.org/all-standards/committees/tr-8
[9] http://www.tiaonline.org/all-standards/committees/tr-8

of random characters that is called an encryption key. This long string of characters is loaded into a radio using one of two manual methods that require handling of the equipment: a hand held device, called a key variable loader (KVL) that is attached to each radio to load the key, or by using a personal computer (PC) with software capable of generating an encryption key attached to a radio.

A more advanced, automated, and costly solution is Over-The-Air-Re-key (OTAR-FIPS 140-2). OTAR uploads and updates existing encryption keys with new keys automatically over the radio system without having to handle each radio individually. In the case of a large agency with thousands of subscriber radios operating on their network, this may be the best solution. The capability to use OTAR requires additional infrastructure and expense. Funding should be identified prior to any procurement. OTAR requires the establishment of a Key Management Facility (KMF) to maintain this capability. In the event that a neighboring jurisdiction has a dedicated KMF available and is open to supporting your agency through a Memorandum of Understanding or Agreement, this would be the most cost-effective option to owning your own KMF. Some federal agencies obtain OTAR support through agreements with federal agencies that have KMF facilities. This approach offers a savings over building independent, stovepipe systems. A good feature of OTAR is the ability to inhibit a radio from using a network, remotely enable a radio access to a network, or to zeroize the radio by removing the encryption key from the radio. OTAR is a cost-effective solution for larger agencies in major metropolitan areas, large regional areas, or statewide systems. The federal government uses OTAR routinely to support encryption needs across the United States.

6.3 Intrinsic Safe Standard

ANSI, the International Society of Automation (ISA), and Underwriters Laboratories (UL) are organizations that develop consensus standards through the participation of manufacturers, regulators, and consultants, as well as standards certification organizations.

There are multiple methods used to certify LMR equipment as intrinsic safe (IS) certified. Within this, LMR equipment falls under Class I Division 1- for use in hazardous locations, which are common environments to emergency responders. Hazardous locations may include areas such as aircraft hangars, fuel storage locations, bulk plants, paint/finishing processing plants, health care facilities, and other areas where excessive combustible dust is present (such as in barges or ships carrying combustible grain and grain elevators or silos, all susceptible to explosions due to the fine dust particles in the air). This does not only apply to radio equipment; IS certification includes other devices, such as light switches, motors, and any device capable of creating an ignition source through a spark or other means to ignite a fire or explosion.

An effort is underway to develop a specific IS standard solely for the certification of LMR equipment used by emergency responders. Additionally, the intrinsic safe subcommittee of TIA (TR-8.2) is the same committee working on the P-25 standards. Agencies with a requirement for IS-certified equipment should contact the manufacturers to identify the status of the new IS standard being developed.

The Occupational Safety and Health Administration (OSHA[10]), under the U.S. Department of Labor promotes requirements for workplace safety. Intrinsic Safety falls under their guidance under their Occupational Safety and Health Standard Number 1910. This standard identifies hazardous locations where IS-certified equipment is required.

6.4 Military Standard 810 Series Test Standards

Military Standard 810 Series Test Standards have been in use for many years and portions of them have been updated. This standard is a selection of tests focused on the environmental engineering considerations and laboratory tests that evaluate equipment under environmental conditions that can be expected during military operations. Tests are identified within the Military Standard Appendix of this procurement guide. The use of this standard dates back to World War II, when the military developed a series of tests to see how well equipment survives under extreme environments.

[10] http://www.osha.gov/pls/oshaweb/owadisp.show_document?p_id=9884&p_table=STANDARDS

7.0 CONCLUSION

Procurements are often time consuming and complex; the ultimate goal is to purchase the right tool for the right job. Buying new and emerging technology isn't as simple as it may seem. In-depth research is required, as is the ability to identify what product meets the requirements, performs to expectations, and is available at a reasonable cost. In today's economy, procurement decisions have taken on more meaning and often receive more scrutiny. Agencies often lack staff with technical backgrounds to make smart decisions when they purchase technologies, so they are at the mercy of sales representatives eager to obtain their business and offer substandard products.

Modern technology is complex; therefore, agencies seeking to procure equipment must have a basic understanding of features and capabilities available. Vendors will often attempt to inject proprietary features in equipment without the buyer's knowledge. Proprietary features often compromise interoperability and force agencies to buy equipment from that vendor. Additionally, purchasing proprietary equipment eliminates competition resulting in increased cost. Some agencies rely on integrators to perform the necessary evaluation of products that meet their requirements and assist in procurements. This too has limitations, as some integrators may align with a single manufacturer. Integrators should identify suitable products that meet the requirements and best value. Grants are often available to assist in the expense of procuring equipment, including radio equipment. Most grants include guidance that provides an outline on how grant funds can be spent in procuring new technologies. Agencies should pay close attention to the directions provided in all grant documents and ensure they are in compliance.

Features, Performance, and Cost

Agencies seek technologies that offer the features that meet or exceed their requirements and perform to their expectations. Performance is critical and must be taken seriously. Users cannot afford to have any technology that fails in the field when it's needed most. Some features may add additional weight to the radio. A ruggedized radio will often increase the weight by a factor of up to 50 percent. Extended battery life/performance also increases weight even with the next-generation of battery chemistries. The addition of multiple radio bands increased the size of the antenna, another area of concern. Since the MBR today is a first generation device, it is hoped that future generations will remove these three concerns and perhaps incorporate next-generation broadband features. Current initiatives with BB/LTE have opened the market for fourth generation (4G) devices that will require the development of a totally new set of standards and a new statement of requirements. Even with the advent of BB/LTE, there will be a gradual transition from legacy LMR systems to modern broadband systems.

As stated previously, the MBR project did not envision MBRs being used at all levels within the emergency response community. Rather, the MBR was envisioned as a tool for communications interoperability at the supervisory, incident commander, and emergency manager level or maintained as part of a set of cache radios ready for deployment during emergencies. One larger fire department reported they issue the MBR across their operations division from the chief to the firefighter since the cost of the MBR is now comparable to a single-band radio.

DHS envisions the MBR being used in myriad scenarios – from state police or wildlife officers patrolling across multiple jurisdictions to county sheriff's deputies supporting agencies within their respective county to firefighters or EMS technicians on calls or called out to support other jurisdictions during mutual aid requests to National Guard civil support teams supporting emergency responders or federal agencies supporting state and local agencies during major events or participating in task forces or special operations.

Depending on the path the BB-LTE takes in the future, the MBR may play a role in providing a capability that may enhance the voice requirements of future solutions. BB-LTE will likely provide the data and video capabilities that the MBR cannot offer today. Whatever the final design provides, there will always be a voice radio communications requirement.

8.0 ACRONYMS

AES	Advanced Encryption Standard
APCO	Association of Public-Safety Communications Officials
BB-LTE	Broadband (see LTE)
CAI	Common Air Interface
CFR	Code of Federal Regulations
DES	Data Encryption Standard
DHS	Department of Homeland Security
DoD	Department of Defense
DoS	Department of State
EIA	Electronics Industries Alliance
EMS	Emergency Medical Services
FCC	Federal Communications Commission
FDMA	Frequency Division Multiple Access
FIPS	Federal Information Processing Standard
GMF	Government Master File
IS	Intrinsically Safe
kHz	Kilohertz
LMR	Land Mobile Radio
LTE	Long-Term Evolution (see BB)
MBR	Multi-Band Radio
MHz	Megahertz
NASTD	National Association of State Technology Directors
NTIA	National Telecommunications and Information Administration
OFB	Output Feedback (OFB-DES)
OTAR	Over-the-Air-Rekey
P-25	Project 25
RF	Radio Frequency
RKB	Responder Knowledge Base
TDMA	Time Division Multiple Access
TIA	Telecommunications Industry Association (see EIA)
ULS	Universal Licensing System
UHF	Ultra-High Frequency
VHF	Very-High Frequency

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APPENDIX

BASIC FEATURES

Basic transceiver features consist of details of what features the radio offers. Most manufacturers offer advanced features or options at additional cost and may include trunking, encryption, over-the-air-rekey (OTAR), Global Positioning System (GPS) location, and others that are broken down into separate categories. This guide provides the user and procurement officials the ability to determine what features are available by manufacturer to meet the users requirements. In addition, the guide provides lists showing receiver and transmitter performance, displays/controls, scan/programming and cloning, encryption, batteries and battery chargers, and more. The guide will also assist the user/procurement officials in understanding what military standards are and how they apply to MBR equipment in use by emergency responders and provide information on training and repairs and warranties.

Single-band operation
Multi-band operation
Channel capacity
Channel spacing: 25.0 wideband, 12.5 narrowband
Channel scanning
Remote speaker/microphone
PC programming:

ADVANCED FEATURES/OPTIONS

Advanced features are generally available at additional expense. Agencies not requiring these features will spend less than buying MBR equipment that is fully capable. Agencies may not require encryption, Project 25 (P25) operations, asset tracking using GPS technologies, or other features. All features both basic and advanced are identified within this guide. Basic and advanced features are generally software applications and not accessories. Accessories are also covered in this guide.

P25 Operation:
- Phase I FDMA (12.5 kHz channels)
- Phase II TDMA (6.25 kHz channels)

Multi-band Operation: May be manufacturer specific; some require this feature to be activated at added expense.

Location Information:
- GPS location capability, internal or external (speaker microphone)
- MDC-1200 signaling

Bluetooth ™

Intrinsically safe: May be manufacturer specific; some require this feature to be activated at added expense; standard/optional

Cloning:

Warranty period/parts & labor:

Encryption:
- OFB-DES
- AES
- OTAR optional (fee)

Before procuring any MBR equipment, it is advisable to first verify that the equipment has been certified by the Federal Communications Commission (FCC) and for Canadian agencies by Industry Canada. The FCC issues Type Acceptance Numbers for the United States, and Industry Canada issues certifications. Applicable FCC Rules for the MBR include Part 80 Maritime Services (Marine) and Part 90 Private Land Mobile Radio Services (Commercial).

MULTI-BAND RADIO PROCUREMENT MATRIX - BASIC FEATURES

MANUFACTURER MODEL NUMBER	TRI-BAND CAPABLE 138-174 MHz VHF, 380-512 MHz UHF, 700/800	CHANNELS: NUMBER OF CONVENTIONAL CHANNELS OR TRUNKED	ANALOG FM WIDE/NARROWBAND	DIGITAL P25 CONVENTIONAL	DIGITAL P25 TRUNKING	P25 VOCODER ENHANCED FULL RATE AMBE+2 VOCODER	ENCRYPTION OFB-DES - AES	HEIGHT/WIDTH/DEPTH WITH ANTENNA (IN)	WEIGHT WITHOUT BATTERY/ANTENNA (OZ)	WEIGHT WITH STANDARD BATTERY AND ANTENNA (OZ)	WEIGHT WITH EXTENDED LIFE BATTERY/ANTENNA (OZ)	SOFTWARE AND FRONT PANEL PROGRAMABLE	INTRINSIC SAFE STANDARD OR OPTIONAL	COMPLEXITY TO USER HIGH/MEDIUM/LOW
1	Y	#	Y	Y	Y	Y	Y	H				Y	Y	H
	N		N	N	N	N	N	W				N	N	M
			O	O	O	O	O	D				O	O	L
2	Y	#	Y	Y	Y	Y	Y	H				Y	Y	H
	N		N	N	N	N	N	W				N	N	M
			O	O	O	O	O	D				O	O	L
3	Y	#	Y	Y	Y	Y	Y	H				Y	Y	H
	N		N	N	N	N	N	W				N	N	M
			O	O	O	O	O	D				O	O	L
4	Y	#	Y	Y	Y	Y	Y	H				Y	Y	H
	N		N	N	N	N	N	W				N	N	M
			O	O	O	O	O	D				O	O	L
5	Y	#	Y	Y	Y	Y	Y	H				Y	Y	H
	N		N	N	N	N	N	W				N	N	M
			O	O	O	O	O	D				O	O	L

NOTES

RECEIVER PERFORMANCE

Receiver Performance Evaluation

How a receiver performs is based on multiple tests that evaluate how well it receives a radio signal and can filter out or reject other signals nearby. All are critical to evaluating receiver performance. This may appear to be complex and it can be. The goal is to purchase equipment with the best performance. Some basic performance measures are:

Receiver Sensitivity: Analog and Digital
Adjacent Channel Rejection
Intermodulation Rejection
Overload Rejection

Receiver Sensitivity - a sensitive receiver can extract a weak signal that may originate at a long distance from the receiver. The transmitter may not have sufficient power or gain resulting in a weak signal that is difficult to receive. Receiver sensitivity is the ability of a receiver to bring in weak signals. Analog and Digital sensitivity are evaluated.

Adjacent Channel Rejection - critical to public safety; the receiver must have the ability to reject strong signals from channels adjacent to or in close proximity to those in use.

Intermodulation Rejection - internal to the receiver; the ability to reject interference within the receiver.

Overload Rejection -the ability to reject strong signals from interfering with receiver, often called receiver overload.

RECEIVER
Frequency Range
Channel Spacing (kHz) 25.0 12.5 kHz
Sensitivity (12 dB SINAD (dBm) analog
Sensitivity (1% BER, 5% BER) digital
P25 Reference Sensitivity
Adjacent Channel Rejection @ 25kHz/dB
P25 Adjacent Channel Rejection @ 12.5 kHz/dB
***Intermodulation (dB)**
Spurious and Image Rejection (dB)
FM Hum and Noise @ 25kHz (dB)
FM Hum and Noise @ 12.5kHz (dB)
Rated/Maximum Audio Output (power in mW)
Rated RF Power Trunked (power in watts)
Rated RF Power Talkaround (power in watts)
Frequency Stability:
Modulation Limiting
Audio Response (in dB)
Spurious and Harmonics (dBc)
FM Hum and Noise @ 25kHz (dB)
FM Hum and Noise @ 12.5 kHz (dB)
Audio Distortion (%)

	MULTI-BAND RADIO PROCUREMENT MATRIX - RECEIVER PERFORMANCE (TYPICAL)													
MANUFACTURER & MODEL NUMBER	RECEIVER SENSITIVITY ANALOG	RECEIVER SENSITIVITY DIGITAL	RECEIVER SENSITIVITY CHANNEL-CHANNEL	ANALOG 12.5 kHz ADJACENT CHANNEL REJECTION (dB)	ANALOG 25.0 kHz ADJACENT CHANNEL REJECTION (dB)	P25 DIGITAL ADJACENT CHANNEL REJECTION (dB)	RECEIVER HUM AND NOISE 12.5 kHz @ VHF/UHF	RECEIVER HUM AND NOISE 12.5 kHz @ 700/800	RECEIVER HUM AND NOISE 25.0 kHz @ VHF/UHF	RECEIVER HUM AND NOISE 25.0 kHz @ 700/800	SPURRIOUS AND IMAGE REJECTION (dB)	INTERMODULATION REJECTION (dB)	RECEIVER AUDIO DISTORTION @ RATED POWER	RATED AUDIO OUTPUT POWER
1														
2														
3														
4														
5														

NOTES

TRANSMITTER PERFORMANCE

Key concerns/criticality
Wireless devices such as radio transmitters require authorizations or certifications before they are marketed within the United States. The FCC has regulatory authority over all wireless devices both licensed and unlicensed brought into the United States. The majority of devices used by emergency responders fall under Chapter 47 of the Code of Federal Regulations (47 CFR).
Manufacturers have their wireless devices tested by accredited labs that measure performance and submit a Declaration of Conformity that verifies that the device meets the technical requirements. Transmitter performance is less complex than receiver performance but can be difficult to understand.

These tests include:
Radio Frequency (RF) Output Power; a measurement that determines the actual power to the radio antenna.
Modulation Characteristics;
Bandwidth;
Spurious Emissions;
Field Strength;
Frequency Stability;
RF Radiation Exposure;

Emission Designators
16K0F3E, 11K0F3E, 8K4F1E, 8K4F1D, 12K00G1E, 12K00G1D, 14K0F3E (H)

MULTI-BAND RADIO PROCUREMENT MATRIX - TRANSMITTER PERFORMANCE - (TYPICAL)

MANUFACTURER MODEL NUMBER	TRANSMITTER OUTPUT POWER VHF 138-174 MHz	TRANSMITTER OUTPUT POWER UHF 380-512 MHz	TRANSMITTER OUTPUT POWER 700/800 MHZ	CONDUCTED AND RADIATED SPURIOUS OUTPUT @ VHF/UHF	CONDUCTED AND RADIATED SPURIOUS OUTPUT @ 700/800	AUDIO DISTORTION	ADJACENT CHANNEL POWER RATIO@12.5 kHz ANALOG CHANNEL	ADJACENT CHANNEL POWER RATIO @ 25 kHz ANALOG CHANNEL	ADJACENT CHANNEL POWER RATIO P25 VHF/UHF 700 MHZ	ADJACENT CHANNEL POWER RATIO P25 VHF/UHF 800 MHZ	TX/HUM AND NOISE @ 12.5 kHz VHF/UHF	TX/HUM AND NOISE @ 12.5 kHz 700/800	TX/HUM AND NOISE @ 25 kHz VHF/UHF	TX/HUM AND NOISE @ 25 kHz 700/800	MODULATION LIMITING @ 12.5 kHz CHANNELS	MODULATION LIMITING @ 25 kHz CHANNELS	ACTIVE NOISE SUPPRESSION
1																	
2																	
3																	
4																	
5																	

FULL KEYPAD, PARTIAL KEYPAD, NO KEYPAD, ENHANCED CONTROL FEATURES (LARGER KNOBS), TOP DISPLAY, ENHANCED TOP DISPLAY, CONTROL KNOB INDENTS

DISPLAY AND CONTROLS FEATURES

Display:
Displays are critical to the user community since they provide multiples lines of text and icons that indicate the channels, modes, battery status, and other icons as provided by individual manufacturers. Surveillance mode, a capability to turn on/off all illumination on the radio, is critical for undercover operations. One issue with using the surveillance mode is that the user must be familiar with the channel settings since the majority of MBR equipment displays the channel information on the front or top display. The side programmable buttons offer a variety of settings and are programmed to meet the user needs. These buttons may be programmed to offer a scan capability, disable squelch on analog channels, and others.

FRONT DISPLAY
TYPE/NUMBER OF LINES/NUMBER OF CHARACTERS PER LINE
FRONT PROGRAMMABLE BUTTONS (NUMBER)
SIDE PROGRAMMABLE BUTTONS (NUMBER)
FRONT KEYPAD DTMF
LED INDICATOR LAMPS
SIDE CONNECTOR FOR ACCESSORIES
CONTROLS:

- --ON/OFF/VOLUME
- --CHANNEL SELECT
- --ENCRYPTION SELECT
- --ZONE SELECT
- --EMERGENCY BUTTON
- --INTERNAL SPEAKER
- --INTERNAL MICROPHONE

ControlS:
Controls consist of all knobs and switches used to turn the MBR on/off, select encryption, zones, as well as to control the volume. Depending upon the operating environment, some disciplines need special capabilities. Firefighters require larger knobs since they wear heavy gloves and require larger channel and volume control knobs. The MBR consists of a front keypad, programmable front, and side buttons,.

MULTI-BAND RADIO PROCUREMENT MATRIX - DISPLAY & CONTROLS FEATURES

MANUFACTURER MODEL NUMBER	FRONT KEYPAD (Y/N-OPTIONAL)	FRONT COLOR DISPLAY (Y/N-OPTIONAL)	TOP DISPLAY (Y/N-OPTION	SURVEILLANCE MODE / DISABLE DISPLAY/LIGHTS	DISPLAY DIMENSIONS	PROGRAMMABLE SIDE BUTTONS OR SOFT KEYS/NAVIGATION KEYS	NUMBER OF LINES & NUMBER OF CHARACTERS PER LINE ON DISPLAY	EMERGENCY BUTTON (Y/N)	TRANSMIT/RECEIVE LED INDICATOR	CHANNEL OR ZONE CAPACITY	GLOBAL POSITIONING SYSTEM (GPS) INTERNAL	GLOBAL POSITIONING SYSTEM (GPS) EXTERNAL	MDC-1200 ANALOG SIGNALLING	INTRINSIC SAFE Y/N STANDARD OR OPTIONAL
1	Y	Y	Y			Y		Y	Y	#	Y	Y	Y	Y
	N	N	N			N		N	N	#	N	N	N	N
	O	O	O			O			O	#	O	O	O	O
2	Y	Y	Y			Y		Y	Y	#	Y	Y	Y	Y
	N	N	N			N		N	N	#	N	N	N	N
	O	O	O			O			O	#	O	O	O	O
3	Y	Y	Y			Y		Y	Y	#	Y	Y	Y	Y
	N	N	N			N		N	N	#	N	N	N	N
	O	O	O			O			O	#	O	O	O	O
4	Y	Y	Y			Y		Y	Y	#	Y	Y	Y	Y
	N	N	N			N		N	N	#	N	N	N	N
	O	O	O			O			O	#	O	O	O	O
5	Y	Y	Y			Y		Y	Y	#	Y	Y	Y	Y
	N	N	N			N		N	N	#	N	N	N	N
	O	O	O			O			O	#	O	O	O	O

NOTES

SCANNING - PROGRAMMING - CLONING

Scanning

The capabilities and how the radio can scan across programmed channels is a critical requirement for some agencies. In the case where disciplines within one agency operate on different or disparate radio bands, it would be assumed that a capability to monitor or scan onto those bands would be critical. This is the case in major metropolitan areas where sufficient channel space did not exist and the agencies were required to migrate onto different radio bands.

The ability to mix analog and digital as well as conventional and trunked channels was one of the requirements identified by the user community. Manufacturers have worked diligently to ensure that software allowed for this capability.

MBR equipment today offers up to 2,000 programmable channels. It is unlikely that any agency will require the programming of all 2,000 channels. The value of having sufficient channel space is that agencies can build multiple code plugs or mission plans for each type of event . One code plug or mission plan may include having all recognized and authorized interoperability channels being programmed into one zone or multiple zones. The DHS National Interoperability Field Operations Guide (http://www.dhs.gov/national-interoperability-field-operations-guide) lists recognized nationwide interoperability channels authorized by the FCC for public safety/emergency response and the National Telecommunications and Information Administration (NTIA) for federal interoperability for law enforcement and incident response.

Programming

Programming features are often complex and required skilled personnel to program equipment. Channel plans, mission plans, or what are commonly known as code plugs are the basis for programming radio equipment. Software used to program equipment can be costly in comparison to other low-end radios. Many programming kits consist of PC software and programming cable using either a serial or USB port. Others require cables and interface devices. MBR manufacturers offer up to 1,200 programmable channels in their radios.

The ability to program manually from the front panel has been identified by users as a requirement. Often called Front Panel Programming (FPP), there are concerns over the security of the radio with this feature. Typical users in the field will not require this capability, but emergency managers, special response teams, and other such as National Guard Civil Support Teams may find this advantageous due to the mobile nature of their mission. Equipment familiarization is critical and training is a must.

Cloning

The ability to clone a radio provides a rapid transfer of the code plug or program from one radio into others with little effort. This feature is valuable when new equipment is purchased, during the realignment of radio system channels and for cache radios that may need to be updated for use with other agencies during an emergency. The limitation is that the radios being cloned may have to be the same model and type and may require a specific cable to properly clone equipment.

	MULTI-BAND RADIO PROCUREMENT MATRIX - SCANNING-PROGRAMMING-CLONING											
MANUFACTURER MODEL NUMBER	PRIORITY SCAN	MULTI-BAND SCAN	MIXED MODE SCAN - CONVENTIONAL - TRUNKED		PC PROGRAMMING WINDOWS 2000 OR XP AT A MINIMUM	PC PGM: CHNL NR, TX/RX FREQ, OP MODE, CHNL, CSQ, CTCSS, ETC.	SOFTWARE ON CD-ROM, DVD, OR MEMORY STICK	PC PROGRAMMING SERIAL OR USB	FRONT PANEL PROGRAMMABLE	FRONT PANEL PASSWORD PROTECTED	RADIO TO RADIO CLONING	PROGRAMMING SIDE CONNECTOR
1	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N		N	N	N	N	N	N	N	N
	O	O	O		O	O	O	O	O	O	O	O
2	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N		N	N	N	N	N	N	N	N
	O	O	O		O	O	O	O	O	O	O	O
3	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N		N	N	N	N	N	N	N	N
	O	O	O		O	O	O	O	O	O	O	O
4	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N		N	N	N	N	N	N	N	N
	O	O	O		O	O	O	O	O	O	O	O
5	Y	Y	Y		Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N		N	N	N	N	N	N	N	N
	O	O	O		O	O	O	O	O	O	O	O

NOTES

ENCRYPTION FEATURES

Encryption

The expense involved with the procurement and maintenance of encrypted communications is often cost prohibitive for many agencies. Smaller agencies may rely on loading encryption into each subscriber unit manually whereas the time and effort to load encryption into subscriber equipment for larger agencies may also be cost prohibitive due to the time and effort involved. Larger agencies requiring encryption will likely seek proposals that include a capability for over-the-air-rekey (OTAR) . The combined cost and level of effort to maintain a key management facility (KMF) may be a determining factor in purchasing this capability.

P25 DES
P25 AES
P25 OTAR
OFB-DES (backward compatibility)

DIGITAL OPERATION
Type of Vocoder: Improved Multi-band Excitation (IMBE tm) (IMBE +2)
Encryption Algorithms: AES, DES-OFB
Encryption Keys: (number)
Encryption Keying: PC, Key loader, P-25 OTAR

The Department of Homeland Security manages the Project 25 Compliance Assessment Program (P25 CAP) and maintains a list of equipment that complies with the P25 suites of standards. Independent labs evaluate equipment and if found in compliance with the P-25 standards are subsequently listed on the Responder Knowledge Base, or RKB website (www.rkb.us). Users are encouraged to use the RKB website as a valued resource for identifying equipment that has been recognized as being P25 compliant Agencies purchasing equipment using federal grant funds should ensure the equipment complies with the P25 suites of standards.

MANUFACTURER MODEL NUMBER	MULTI-BAND RADIO PROCUREMENT MATRIX - ENCYPTION-OFB DES/AES											
	ENCRYPTION DIGITAL OFB-DES	ENCRYPTION DIGITAL AES (FIPS 140)	ENCRYPTION P25 OVER-THE-AIR-REKEY (OTAR)	KEY ZEROIZATION - SELECTIVE KEY OR ALL KEYS	NUMBER OF ENCRYPTION KEYS	NUMBER OF KEYS - COMBINED OFB-DES AND AES	KEYFILL PC	KEYFILL Key Variable Loader (KVL) ™ DEVICE	INFINITE KEY RETENTION	PROPRIETARY ENCRYPTION KEY LOAD CABLE REQUIRED		
1	Y	Y	Y	Y	#		Y	Y	Y	Y		
	N	N	N	N			N	N	N	N		
	O	O	O	O			O	O	O	O		
2	Y	Y	Y	Y	#		Y	Y	Y	Y		
	N	N	N	N			N	N	N	N		
	O	O	O	O			O	O	O	O		
3	Y	Y	Y	Y	#		Y	Y	Y	Y		
	N	N	N	N			N	N	N	N		
	O	O	O	O			O	O	O	O		
4	Y	Y	Y	Y	#		Y	Y	Y	Y		
	N	N	N	N			N	N	N	N		
	O	O	O	O			O	O	O	O		
5	Y	Y	Y	Y	#		Y	Y	Y	Y		
	N	N	N	N			N	N	N	N		
	O	O	O	O			O	O	O	O		

NOTES

BATTERIES: RECHARGEABLE AND NON-RECHARGEABLE

Batteries are rated according to their capacity - the quantity of electrical power delivered to the device measured in ampere-hours (Ah) delivered under conditions of discharge, use, or duty cycle. The higher the rating, the longer the battery will last. Batteries are rated by duty cycles. The explanation below may provide a better understanding on how batteries are rated.

For rechargeable batteries, the 5-5-90 testing consists of the measurement of battery performance, or duty cycle, where the attached radio is set to receive 3 seconds, transmit 3 seconds, and sit in standby for 54 seconds.

For non-rechargeable batteries such as alkaline and lithium disposable batteries, the 10-10-80 testing consists of the measurement of battery performance, or duty cycle, where the attached radio is set to receive 6 seconds, transmit 6 seconds, and sit in standby for 48 seconds. Duty cycle testing uses a fully-charged radio battery and conducts an evaluation over a period of time until the battery no longer powers the radio. Some manufacturers offer a battery eliminator. This device is basically a non-functional battery case with two long wires that protrude from the case. Battery eliminators allow the direct connect between the portable radio and an external DC voltage source.

Rechargeable batteries:

Nickel Cadmium (NiCD) batteries were the first rechargeable batteries used for portable radios. Some manufacturers are discontinuing production of NiCD batteries. Today, multiple chemistry batteries are available and are generally replacing NiCD batteries and include Nickel Metal Hydride (NiMH), Lithium Ion (Li-Ion), and Lithium Polymer (LiPo) batteries. These tri-chemistry batteries differ in size and capacity. Li-Ion and NiMH batteries are about the same size and weight, but the NiMH has a higher Ah rating than the NiCD and are susceptible to weather extremes. The NiCD can operate in more severe weather than the NiMH. On the other hand, the positive trade off is that NiMH batteries are not susceptible to the “memory effect” that the NiCd suffers from; the Li-Ion battery may be lighter in weight, but is more expensive. The Li-Ion is not prone to “memory effect” common to NiCD batteries. The memory effect that plagues the NiCD battery resulted in battery manufacturers developing battery conditioners. If properly used, the conditioner takes a battery, fully drains it, and then recharges it. This provides a complete discharge/recharge cycle, avoiding memory retention. NiCD batteries contain cadmium and therefor require special disposal and cannot be tossed into the trash.

Li-Ion batteries differ from LiPO batteries in that Li-Ion batteries provide greater energy capacity than LiPO, but LiPO cells are unique in that they can be shaped into any configuration and are lighter; Li-Ion batteries are generally cylindrical but are considerably more expensive.

AA Alkaline clamshell disposable battery housing:

Most manufacturers offer battery packs that use disposable AA alkaline or AA lithium batteries. AA batteries are rated at 1.2 - 1.5 volts and have a shelf life of up to about 6 years. Quality of the product and climate conditions where the batteries are stored may have an effect on the use expectancy. The cost of an AA alkaline battery is considerably less than the AA lithium.

Intrinsically-safe batteries are slightly different than other batteries available. The housing that holds the battery to the radio is the use of rubber gaskets around any area where the battery connects to the radio. The batteries may also fit more snugly to the radio. Another indicator is that many manufacturers use a green label to identify an intrinsically-safe battery.

Battery eliminator:

Some manufacturers offer a battery eliminator. These devices are basically battery cases similar to clamshells but have two wires that allow the portable radio to be connected to an alternative DC voltage source either at a fuse box, cigarette lighter or other alternate source.

***NOTE: Follow manufacturers' instructions for the proper disposal of all batteries. NiCD contains a toxic heavy metal/cadmium, a hazardous waste material under the Environmental Protection Agency. Consult your local landfill for proper disposal practices.**

MANUFACTURER	MULTI-BAND RADIO PROCUREMENT MATRIX - BATTERIES												
	BATTERY RECHARGEABLE NiCD	BATTERY RECHARGEABLE NiMH	BATTERY RECHARGEABLE Li-ion	BATTERY ALKALINE/DISPOSABLE BATTERY PACK-CLAM SHELL	BATTERY LITHIUM/DISPOSABLE BATTERY PACK-CLAM SHELL	BATTERY DISPOSABLE	BATTERY INTRINSIC SAFE		BATTERY ELIMINATOR				
1	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**				
	N	**N**	**N**	**N**	**N**	**N**	**N**		**N**				
2	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**				
	N	**N**	**N**	**N**	**N**	**N**	**N**		**N**				
3	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**				
	N	**N**	**N**	**N**	**N**	**N**	**N**		**N**				
4	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**				
	N	**N**	**N**	**N**	**N**	**N**	**N**		**N**				
5	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**	**Y**		**Y**				
	N	**N**	**N**	**N**	**N**	**N**	**N**		**N**				

NOTES **Intrinsic Safe Options:**
Factory Mutual (USA) and CSA (Canada)

BATTERY CHARGERS

Manufacturers offer a variety of battery chargers. Some will only recharge specific types of chemistries such as NiCD, NiMH, Li-Ion, etc. Chargers come in a variety of forms with multiple options. Through your identified requirements, you should be able to identify the type of charger you need. In some cases, you may need a variety of chargers due to the potential mix of different battery chemistries in use.

Here is a sampling of the types of chargers:
-Desktop chargers: single bay, two bay, six bay.
-Single-chemistry chargers: NiCD-only, NiMH-only, Li-ION-only
-Tri-chemistry chargers: NiCD, NiMH, Li-ION
-Mobile chargers: 12 VDC or dual AC/DC

Desktop chargers are common in many locations and most agencies keep spare batteries available for users. Six bay chargers are excellent solutions for cache radios or for charging spare batteries in a command post or office. Those chargers with an IP address may allow access via the internet to check the battery charge status in advance of any deployments. Some manufacturers offer dual power AC/DC chargers that can be used as desktop (AC) or mobile (DC) chargers.

Mobile chargers are a solution for agencies that do not have sufficient portable radios and chargers to issue one to each responder. The one drawback is the potential lack of space within the mobile platform. Most patrol vehicles are already filled with equipment in their electronics consoles, so space is at a premium.

Tri-chemistry chargers are offered today that will charge NiCd, NiMH, and Li-Ion batteries. These chargers will automatically identify the type of chemistry and charge accordingly. These chargers may also be called battery conditioners. A battery conditioner will take a partially used battery, discharge it, and then recharge it. Some offer a display that shows the battery status, discharge, charging, or a fault light that indicates the battery needs to be replaced. Some basic featured chargers offer an indicator light or display the status of the battery being charged using a combination of colors and flashing colors to provide the status of the battery. Flashing colors and/or steady colors indicate the recharge status. Colors vary and flashing codes differ by manufacturer, with the majority using red or yellow lights. Some chargers offer a combination of colored lights and small liquid crystal displays that provide the battery status.

Some chargers have a capability to monitor the charge rate and condition of batteries via the internet with each charger having an IP address. This feature would be of value to agencies that maintain large cache radio inventories or spare batteries by allowing the remote monitoring of the battery charge status.

MANUFACTURER	MULTI-BAND RADIO PROCUREMENT MATRIX - BATTERY CHARGERS												
	BATTERY CHARGER SINGLE BAY	BATTERY CHARGER TWO BAY	BATTERY CHARGER SIX BAY		BATTERY CHARGER SINGLE BAY TRI-CHEMISTRY	BATTERY CHARGER TWO BAY TRI-CHEMISTRY	BATTERY CHARGER SIX BAY TRI-CHEMISTRY		BATTERY CHARGER MOBILE		INTELLIGENT BATTERY CHARGER/CONDITIONER		
1	**Y**	**Y**	**Y**		**Y**	**Y**	**Y**		**Y**		**Y**		
	N	**N**	**N**		**N**	**N**	**N**		**N**		**N**		
2	**Y**	**Y**	**Y**		**Y**	**Y**	**Y**		**Y**		**Y**		
	N	**N**	**N**		**N**	**N**	**N**		**N**		**N**		
3	**Y**	**Y**	**Y**		**Y**	**Y**	**Y**		**Y**		**Y**		
	N	**N**	**N**		**N**	**N**	**N**		**N**		**N**		
4	**Y**	**Y**	**Y**		**Y**	**Y**	**Y**		**Y**		**Y**		
	N	**N**	**N**		**N**	**N**	**N**		**N**		**N**		
5	**Y**	**Y**	**Y**		**Y**	**Y**	**Y**		**Y**		**Y**		
	N	**N**	**N**		**N**	**N**	**N**		**N**		**N**		

NOTES

MILITARY STANDARD

Most military standards requirements are based on the MIL-STD 810 - Environmental Test Methods and Engineering Guide to ensure that the equipment is of high quality and mechanically sound. This applies to both portable and mobile MBR equipment. We have included the mobile MBR in this procurement guide since manufacturers are beginning to conduct the research and development of a higher-power mobile version of the MBR.

Below is a list of military standards that should be available in any MBR product.

Method 500.4 Low Pressure Procedure II - Operation
Method 501.4 High Temperature Procedure I - Storage
Method 502.4 Low Temperature Procedure I - Storage
Method 503.4 Temperature Shock Procedure I
Method 505.4 Solar Radiation Procedure I - Cycling for Heat Effects
Method 506.4 Rain Procedure I - Blowing Rain Procedure II - Drip
Method 507.4 Humidity Procedure II - Induced
Method 509.4 Salt Fog Procedure I - Aggravated Screening
Method 510.4 Sand and Dust Procedure I - Blowing Dust
Method 514.5 Vibration Procedure I, Category 10 - Minimum Integrity Test (3 axes)
Method 516.5 Shock Procedure I - Functional Shock Procedure IV – Transit Drop Procedure VI – Bench Handling

In addition, a water emersion test should be conducted to verify that the MBR can survive being emerged in water to a depth of 6 feet for a period of 30 minutes.

MANUFACTURER MODEL NUMBER	MULTI-BAND RADIO PROCUREMENT MATRIX - MILITARY STANDARD 810-SERIES												
	500.4 Low Pressure Procedure I, II	501.4 High Temperature Procedure I, II	502.4 Low Temperature Procedure I, II	503.4 Temperature Shock Procedure I	505.4 Solar Radiation Procedure I	506.4 Rain Procedure I Blowing Rain	509.4 Salt Fog Procedure I Aggravated Screening	510.4 Sand and Dust Procedure I, II Blowing Dust	512.4 Immersion (2M) Procedure I	516.5 Shock Procedure I Functional Shock Procedure I, IV	514.5 Vibration Procedure I Category 10	516.5 Shock Procedure I Functional Shock Procedure I, IV	507.4 Humidity Procedure II Induced
1	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N	N	N	N	N	N	N	N	N	N	N
2	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N	N	N	N	N	N	N	N	N	N	N
3	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N	N	N	N	N	N	N	N	N	N	N
4	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N	N	N	N	N	N	N	N	N	N	N
5	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	N	N	N	N	N	N	N	N	N	N	N	N	N

NOTES

TRAINING

Most manufacturers offer multiple training options. Some options include:

- Printed training guides
- CD or other media
- On-line
- In-house: Technician
- In-house: User
- In-house: Train-the-Trainer
- In-house: Secondary Training Provider

The majority of manufacturers provide operator and training manuals on CDs due to the size and cost of printed manuals. Agencies announcing RFPs for larger purchases should include the cost estimate for in-house training in their solicitation. User training may be cost prohibitive for larger agencies, so a train-the trainer session may be the best option. Some agencies may have training divisions capable of reviewing training materials and incorporate their own in-house training . Smaller agencies may have to rely on the use of printed training guides. Agencies may also approach their radio repair contractors to obtain a cost proposal for conducting in-house user training.

MANUFACTURER	MULTI-BAND RADIO PROCUREMENT MATRIX - TRAINING												
	PRINTED TRAINING MANUAL	CD TRAINING MANUAL	ON-LINE TRAINING MANUAL	IN-HOUSE TRAINING TECHNICIAN	IN-HOUSE TRAINING USER	IN-HOUSE TRAINING TRAIN-THE-TRAINER	IN-HOUSE TRAINING SECONDARY PROVIDER						
1													
2													
3													
4													
5													
NOTES													

REPAIRS & WARRANTIES

The average life expectancy for portable radios is seven years due to normal wear and tear from daily use including them often being shared between officers around the clock. High failure items for portable radios include antennas, switches, knobs, and displays. Antennas appear to be the highest failure rate due to size, abuse, and exposure to the elements. MBR equipment built to military standards generally have a lower failure rate.

Warranty repairs do not cover misuse, abuse, or unauthorized repairs by non-approved facilities and must be conducted by authorized service centers or facilities.

Depending upon the unit cost and reliability of the individual product , it may not be cost effective to pay a higher price for an extended warranty that is generally only for two years.

Some manufacturers offer spare parts for field repairs or internal radio shop repairs that may not void warranties due to tampering or unauthorized modifications. Parts that do not require repairs by factory-authorized service centers/facilities may include antennas, knobs, batteries, and belt clips. Intrinsic-safe certified radios may require factory-authorized service to ensure the radio still meets the certification.

Some manufacturers offer full panel replacements that allow the user to replace the front display, speaker, and keypad and the top that includes the antenna connector, switches, and knobs. Conduct thorough research to determine what manufacturers offer this and if it is affordable to maintain spare parts and a requirement for these parts.

MANUFACTURER MODEL NUMBER	MULTI-BAND RADIO PROCUREMENT MATRIX - REPAIRS & WARRANTIES												
	REPAIRS FIELD REPAIRABLE (Y/N)		REPAIRS FACTORY RETURN		WARRANTY (STANDARD-IN-YEARS)		WARRANTY (EXTENDED-IN-YEARS)						
1	Y												
	N												
2	Y												
	N												
3	Y												
	N												
4	Y												
	N												
5	Y												
	N												
NOTES													

ACCESSORIES

Some manufacturers include standard accessories that are included with each radio sold but special accessories may not be available from the original manufacturers. Specialty accessories are generally identified by the user community and built by secondary markets. Caution should be used when procuring secondary market accessories as any modifications or damage to the equipment may void the warranty.

The list allows the user to select what accessories are required by the user. After market accessories are often of similar quality to original manufacturers products and may in fact be identical since some manufacturers purchase accessories from the secondary markets and brand the accessories with their trademark.

A listing of several common accessories are identified below including holsters , headsets, and various microphones. It may be advantageous to conduct market research to match the requirement to the best accessory.

MANUFACTURER	MULTI-BAND RADIO PROCUREMENT MATRIX - ACCESSORIES-HOLSTERS - MICROPHONES													
	HOLSTER NYLON	HOLSTER LEATHER	HOLSTER SWIVEL	HOLSTER CHEST PACK SPECIAL OPERATIONS	EXTERNAL SPEAKER MICROPHONE LARGE	EXTERNAL SPEAKER MICROPHONE SMALL	EXTERNAL SPEAKER MICROPHONE WITH GPS	EXTERNAL SPEAKER MICROPHONE WITHOUT GPS	ACTIVE NOISE SUPPRESSION MICROPHONE	EXTERNAL SPEAKER MICROPHONE INTRINSIC SAFE	SURVEILLANCE MICROPHONE THROAT	SURVEILLANCE HEADSET	BONE MICROPHONE	BLUETOOTH MICROPHONE
1														
2														
3														
4														
5														
NOTES														

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