Portable Radio Repeaters for Indoor and Subterranean Environments

Market Survey Report

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FOREWORD

The National Urban Security Technology Laboratory (NUSTL) is a federal laboratory organized within the U.S. Department of Homeland Security (DHS) Science and Technology Directorate (S&T). Located in New York City, NUSTL is the only national laboratory focused exclusively on supporting the capabilities of state and local first responders to address the homeland security mission. The laboratory provides first responders with the necessary services, products, and tools to prevent, protect against, mitigate, respond to, and recover from homeland security threats and events.

NUSTL manages the SAVER program, which conducts objective assessments and validations on commercially available equipment and systems and develops knowledge products that provide relevant equipment information to the emergency responder community. The SAVER program mission includes:

- Conducting impartial, practitioner-relevant, operationally oriented assessments and validations of emergency response equipment.
- Providing information, in the form of knowledge products, that enables decision-makers and responders to better select, procure, use and maintain emergency response equipment.

SAVER program knowledge products provide information on equipment that falls under the categories listed in the DHS Authorized Equipment List (AEL), focusing primarily on two main questions for the responder community: “What equipment is available?” and “How does it perform?” These knowledge products are shared nationally with the responder community, providing a life- and cost-saving asset to DHS, as well as to Federal, state and local responders.

NUSTL is responsible for all SAVER activities, including selecting and prioritizing program topics, developing SAVER knowledge products, coordinating with other organizations and ensuring flexibility and responsiveness to first responder requirements.

NUSTL provides expertise and analysis on a wide range of key subject areas, including chemical, biological, radiological, nuclear and explosive weapons detection; emergency response and recovery; and related equipment, instrumentation and technologies. In support of this tasking, NUSTL conducted a market survey of portable radio repeaters for indoor and subterranean environments. This equipment falls under AEL reference number 06CP-01-REPT, titled “Repeaters.”

Visit the SAVER website at http://www.dhs.gov/science-and-technology/SAVER for more information on the SAVER program, or to view additional reports on radio repeaters and other technologies.

Visit the NUSTL website at https://www.dhs.gov/science-and-technology/national-urban-security-technology-laboratory, or contact NUSTL@hq.dhs.gov for more information.

U.S. Department of Homeland Security

SAVER

System Assessment and Validation for Emergency Responders

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EXECUTIVE SUMMARY

Radio communications are essential to emergency response operations. Often times, communications in indoor and underground areas are degraded due to poor radio coverage and obstructions to line of sight. One solution to this problem is using a portable radio repeater. A radio repeater is a device that receives a radio's signal and retransmits it at a higher power level to increase its effective range. Portable radio repeaters can be deployed in indoor and subterranean environments as needed to increase radio coverage and ensure effective communications in emergency response operations.

NUSTL, through its Systems Assessment and Validation for Emergency Responders (SAVER) program, and with the support of the Pacific Northwest National Laboratory (PNNL), conducted a market survey of portable radio repeaters for indoor and subterranean environments. Information was gathered from a "technology scouting request" submitted to the DHS S&T Technology Scouting and Transition group in July 2020; a government-issued request for information (RFI) posted on the System for Award Management (SAM) website in September 2020; a SAVER focus group held in October 2020' and independent research conducted from July 2020 through March 2021.

This market survey identifies 20 commercially available portable radio repeaters deployable for indoor or underground use and ranging in price from $3,700 to $51,000. The devices in this report are all human-portable, contained within a protective enclosure (such as a ruggedized suitcase), and support the P25 radio standard. Performance of these products has not been independently verified by NUSTL.

Emergency response agencies that consider purchasing portable radio repeaters should carefully research the overall capabilities, limitations, and technical specifications of each system in relation to their agency's operational needs.

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1.0 INTRODUCTION

Radio repeaters are commonly used by first responders to extend the coverage range of their communications systems. This market survey report (MSR) includes a technical discussion on principles of operation of portable radio repeaters and a brief description of the features, capabilities and specifications of 20 commercially available repeaters. This MSR is based on information gathered from June 2020 to March 2021, from vendor websites, internet research, industry publications, a technology scouting report and a government issued request for information that was posted on the System for Award Management (SAM) beta website.

For inclusion in this report, the radio repeaters had to meet the following criteria as recommended by first responders:

- The product is available to emergency responder organizations as a commercial off-the-shelf (COTS) or government off-the-shelf (GOTS) product.
- The product is deployable as needed for different indoor and underground emergency response operations, i.e., the product is not a fixed installation solution.
- The product is compatible with P25 radio systems.
- The product is contained within a protective enclosure.
- The product is human-portable, i.e., the combined weight of the repeater and the enclosures is under 50 pounds (approximately 22.6 kilograms) or the enclosure is equipped with wheels if the combined weight is over 50 pounds.

No cell-on-wheels (COW) or cell-on-light-truck (COLT) systems are included in this MSR. Products that exclusively support satellite communications (SATCOM) are also excluded from this MSR.

Due diligence was performed to develop a report that is representative of products currently available in the marketplace.

2.0 RADIO REPEATERS OVERVIEW

A radio repeater is an optional component in a wireless communication system. It is a specialized radio network component that contains both a receiver and a transmitter. Repeaters are used by first responders to increase the effective communications coverage area for portable radios, mobile radios, or base stations that otherwise might not be able to communicate with one another. The repeater's receiver is tuned to the frequency used by the original signal's transmitter for incoming signals, and the repeater's transmitter is tuned to the frequency used by the original signal's receiver. The incoming signal is rebroadcast to the radio network on a different frequency, usually with higher power and from a location that enables effective communications.

Radio frequency (RF) communications may occur with or without the assistance of a repeater. Simplex (also known as "talkaround" by some manufacturers) communication refers to transmission from one radio directly to another without the use of a repeater. Simplex radios transmit and receive on the same frequency and are typically used when only a small coverage area is required. A drawback to simplex communication is that users cannot simultaneously receive and transmit signals. This allows the users to transmit and receive signals simultaneously on the repeater. Duplex communication may or may not include the use of a radio repeater. However, a radio repeater can only support duplex communication.

The rest of this section provides information on a variety of factors that should be considered when purchasing communication equipment, including secure communications compatibility, RF transmission power and its impacts on coverage range, and digital communications compatibility.

Many of the repeaters in this report are equipped with self-contained transmitters and receivers. The settings described in the following sections are adjusted directly through the repeater in these models. Some repeaters rely on third party handheld or dashboard-mounted radios embedded in the repeater enclosure to serve as the transmitter and receiver. In these repeaters, some settings are adjusted through the radio. This may allow for improved flexibility in repeater configuration.

2.1 CURRENT TECHNOLOGIES

2.1.1 RF BANDS AND BROADCAST MODES

Wireless systems (radios) transmit data and voice information using a specific radio frequency to other radios tuned to the same frequency. The radio repeater products included in this guide use RF frequencies between 20 MHz and 1000 MHz. This range of RF frequencies is within the high frequency (HF) band (below 136 MHz), the very high frequency (VHF) band (136 MHz to 300 MHz) and the ultrahigh frequency (UHF) band (300 MHz to 3 GHz). While the frequency range from 700 MHz to 1000 MHz falls under the UHF band, it is also referred to as the 700/800/900 MHz bands. Note that the 900 MHz band (900 MHz to 1000 MHz) is generally not used for public safety communications, but is capable of P25 operations. Throughout this Market Survey Report, the UHF designation is given to frequencies between 300 and 520 MHz while 700/800/900 is used for frequencies between 700 and 1000 MHz.

The Federal Communications Commission (FCC) regulates and allocates U.S. RF spectrum usage to non-federal government users. The spectrum allocation process is by radio frequency band (e.g., VHF, UHF) and purpose (e.g., public safety, TV channels, commercial aviation, amateur radio), creating frequency bands within which radio repeaters must operate.

The radio repeaters listed in this MSR generally operate in a single frequency band. Some repeaters can be configured to include cross-band interoperability (i.e., the repeater receives signals in one frequency band and re-transmits signals in a different frequency band and vice versa). A frequency band designation of HF/VHF/UHF indicates usage of contiguous frequencies between these three bands. Public safety agencies should confirm that their repeaters use the same frequency as their radios, for example the radio transmit frequency is the repeater's receive frequency . Each radio is configured to operate on frequencies commonly known as channels or pairs assigned by the local RF spectrum manager or spectrum coordinator in order to minimize radio transmitter interference or crosstalk with other users and to optimize the overall RF band utilization in a given geographical area.

A drawback to the channel assignment process becomes evident when mobile response teams must communicate with response teams from different agencies: the mobile response teams' radios must be reconfigured to enable interagency communications. To mitigate this issue, spectrum managers will often allocate mutual aid channels that can be used for communications during operations requiring personnel from different agencies and jurisdictions. Radios and repeaters should also be capable of using mutual aid frequencies and frequencies used by other departments to allow for interoperable communications depending on the repeater model used.

Public safety agencies should also confirm that the operating mode (analog or P25 digital) of a repeater conforms with radios used by the agency. Analog radios convert the user's voice into an electrical signal, then transmit that signal. Digital radios convert a voice into an electrical signal, encode the electrical signal into a digital signal which is then transmitted. In general, digital radio communications provide greater functionality (including more consistent audio quality, better spectrum efficiency, and secure encryption techniques) but at a higher price point than analog communications. Many agencies currently use digital radios or are migrating to digital radios from analog. It should be noted that repeaters with embedded third party radios (as opposed to self-contained transmitters and receivers) may decode received digital signals and then re-encode the transmitted signal.

All the repeaters in this MSR support the P25 standard and are therefore compatible with both analog and digital P25 radios. More information on this standard is provided in section 2.3.1.

2.1.2 COVERAGE RANGE FACTORS

A radio repeater's primary function is to extend the range of RF communications. As such, public safety agencies need to consider how this extension is achieved. The increase in coverage range is primarily accomplished by rebroadcasting received wireless signals at a higher transmission power and with better performing antennas.

RF transmission power refers to the maximum output power of the transmitter, and this value will vary based on a number of factors. For portable radios and repeaters, a high output power leads to shorter operational time on batteries. A signal with low transmission output power can be difficult for other radios or repeaters to pick up.

Higher RF transmit power may not directly result in more effective communications, however, due to obstructions or reflections that may be in the RF signal pathway. In repeaters with third party embedded radios (as opposed to self-contained transmitters and receivers), transmission power may be dependent on the radio instead of a signal amplifier in the repeater.

Other factors that affect coverage range include receiver sensitivity, receiver selectivity, transmitter antenna gain and receiver antenna gain. The transmitter's power may be user-controllable, but the receiver's sensitivity is a product specification that refers to the smallest signal the receiver can use for comprehensible communications. Receiver selectivity, often measured in decibels (dB), is the ability of the receiver to respond to a certain signal only. A repeater's receiver sensitivity may allow it receive signals from both a tactical radio and another wireless device, such as a remote sensor, but the receiver selectivity allows the repeater to ignore the signal from the remote sensor.

The user can also configure the repeater system with antennas that provide more directionality and higher signal gain (e.g., Yagi, log-periodic) or omni-directional (e.g., whip antenna) coverage and lower signal gain. Antennas to be used with the repeater should be selected to improve the signal-to-noise ratio on both the transmitting and receiving end of the repeater to allow for significant improvements in coverage range. When in a building or in a subterranean environment, some systems may already be installed at the site to boost the signal range within the environment.

2.1.3 SECURE COMMUNICATIONS METHODS

The ability to encrypt and decrypt communication signals is crucial to securing communications. Encryption transforms data so only approved parties can decrypt and transform it into a comprehensible voice, message, or text. Analog encryption is not typically used.

The security of digital encryption is commonly measured by the length of the key. The key is a secret number or password that must be known by all radio operators in the group in order to decrypt the call. This allows private radio communication and prevents outsiders from decoding intercepted communications. The type of encryption that is selected depends on the type of information being protected and will vary based on the manufacturer. NIST, the Federal Partnership for Interoperable Communications, and the National Law Enforcement Communications Center, which issues national interoperability encryption keys, all strongly recommend that public safety organizations use AES 256 for encryption [1].

Agencies should establish policies and procedures to control encryption key access for communications. Since keys are digitally stored on handheld radios, a plan also needs to be in place to determine what to do if a radio with the key saved on it is lost or stolen. This contingency is commonly managed by having more than one encryption key.

When purchasing a radio repeater, public safety agencies need to confirm that, at the very least, the repeater can re-transmit encrypted signals. Public safety agencies may select a repeater that can decrypt received signals and re-encrypt signals before re-transmitting. In this case, agencies should ensure that the encryption method used by the repeater matches that used by the radio and that end-to-end encryption is not required. Similar to the need to coordinate frequencies, agencies should also confirm that their encryption methods match those used by partner agencies to enable interoperable communications. It should be noted that repeaters with embedded third party radios (as opposed to self-contained transmitters and receivers) may decrypt received signals and then re-encrypt the transmitted signal.

2.1.4 PHYSICAL SPECIFICATIONS AND FEATURES

Public safety agencies should also consider physical specifications and features of a radio repeater. Size and weight are important to consider, especially for portable repeaters, which may often times be deployed in hard-to-reach areas with limited physical access. For inclusion in this report, repeaters were limited to human-portable systems with a weight of up to 50 pounds (lb). Six repeaters over this weight limit are nevertheless included in this summary, because features of their protective enclosures, such as wheels, allow for greater portability despite their weight. Regarding the size of the products, total exterior dimensions (the sum of length, depth, and height measurements) ranged from 25 to 62 inches.

Sources of electrical power should also be considered. Power source options include an internal battery, 120 V ac, and the use of external dc connections for vehicle use, solar panels, or secondary batteries for some models. Battery life, battery weight and radio repeater transmitting power represent significant operational tradeoffs. Each option for equipping a response team, whether internal battery packs, 120 V ac power, or solar panels, has logistical drawbacks. Some portable repeaters have internal battery packs, which allow for greater flexibility in positioning the repeater as the repeater does not need to be anchored to an external power source. On the other hand, external power sources offer a longer run-time with the tradeoff of limited options for placement. Agencies should include a properly rated extension cord with the repeater. A repeater's power consumption is lower when not actively transmitting or receiving. This is an important factor to keep in mind for maximizing the battery life of repeaters.

Other physical features to consider include cross-band functionality and ease of local repeater control and configuration. Many of the repeaters in this MSR include integrated transmitters and receivers and do not require any user interactions after being deployed. However, some of the repeaters in this report require active usage after deployment and rely on separate radio handsets to be embedded in the repeater housing to serve as the transmitter and receiver. Agencies should verify that these types of repeaters can provide power to the desired embedded radios. While more complex systems may be appropriate for larger first responder agencies, they may not be ideal for smaller organizations with limited communications resources, including handheld radios and technicians. Agencies should consider ease of use of local controls when selecting a portable radio repeater.

It may be possible to interface the local repeater to another radio system, and this requires special consideration. There are two primary approaches, backhaul connections or a "donor" radio. Backhaul connections may use cellular, SatCom, or other methods to provide network connectivity to the local repeater. The P25 standard DFSI (Digital Fixed Station Interface) provides a vendor-agnostic standard for connection into a P25 system, and some repeaters and radio systems support this option. A "donor" radio approach uses a radio to bridge between the local communications (such as simplex/talkaround) and another system (such as trunking). Special planning is required to ensure that the communications operate as expected when deployed in the field.

2.1.5 CUSTOM-BUILT VARIATIONS

If the repeater products listed in this MSR do not meet the needs of an emergency response agency, the agency may be able to work with a vendor to create a custom-built repeater. A custom-built repeater is a not-commercially-available variation on a base model. This variation may be an enhanced specification, such as a higher transmission power, or an additional feature, such as a satellite communication (SATCOM) interface. These custom repeaters can be built around a rack-mounted model initially intended for fixed installations, allowing for higher transmission power and common part usage. In these cases, the repeater is usually embedded into a protective enclosure and can be equipped with an additional power source.

This MSR lists only commercially available products and therefore custom-built repeaters are not included. However, most of the vendors mentioned in this report will also customize a repeater to a user's needs if necessary. More information on customization can be obtained directly from the vendor via the contact information listed in section 4.0.

2.1.6 OTHER INTEROPERABILITY CONSIDERATIONS

Interoperability is a process of connecting different users, traditionally using different radio systems and potentially different communication technologies (e.g., cellular phones, radios, repeaters), allowing for seamless communication with one another directly. An example of interoperability is the compatibility of a local police department's radio system with a different jurisdiction, or the Federal Emergency Management Agency (FEMA) National Radio System (FNARS) (if the HF frequency band is used). The DHS *National Interoperability Field Operations Guide* (NIFOG) [2] has additional relevant information on rules and regulations for use of interoperability channels and tables of frequencies and standard channel names.

As mentioned in sections 2.1.1. and 2.1.3, coordinated transmission frequencies and encryption methods are essential to interoperability. Proprietary radio repeater features and functions can also limit the communication system's interoperability.

A radio repeater that can be reconfigured or reprogrammed may provide the capability to add or delete channels, but this function may be limited depending on the frequency bands used. Special purpose software is used to configure channels and security.

2.2 APPLICATIONS

2.2.1 COMMUNICATIONS IN ENVIRONMENTS WITH LIMITED COVERAGE

Repeaters enable extended communication ranges in non-line-of-sight, indoor, or subterranean applications by transmitting the relayed wireless signal with additional power or an alternative frequency. If possible, the repeater is physically located in a better location (e.g., on top of a tall building or with line-of-sight to both the transmitter and receiver) than the initiating transmitter or receiver radios. Many applications have physical obstructions that cause degraded signal reception (e.g., building structural components, skyscrapers, forests, wireless signals reflecting from surfaces (multi-path), or other sources of wireless signal interference such as other radios or repeaters operating nearby (such as those on a Distributed Antenna System (DAS)).

Incorporating a wireless signal quality assessment into the process of locating where to place the repeater increases confidence that the device will enable effective communication with teams. This assessment includes determining the received signal level and the presence of interfering sources. The assessment should also consider the location of the deployed repeater, the locations of radios or other receivers that will communicate with the repeater, and how factors such as distance or line of sight obstructions may impact signal quality.

2.2.2 DEPLOYMENT CONFIGURATIONS INDOORS OR UNDERGROUND

Various deployment configurations are possible to enhance radio coverage in indoor and underground environments. These configurations include stand-alone suitcase (e.g., Pelican case) and rack-mounted options, optional networking capabilities, antennas, power amplifiers, and external batteries.

Wireless system performance can be significantly enhanced by the antenna selected for the application. Omnidirectional antennas (e.g., portable radio antennas) typically have low or negative gain, but allow equivalent transmission and reception performance in all directions perpendicular to the antenna's centerline. Directional antennas (e.g., Yagi, panel, screened dipole array) provide higher gain (longer range) but require the antenna to be optimally positioned.

Radio repeater installation starts by determining if the repeater requires separate antennas for transmitting and receiving RF signals. To simplify deployment, some repeaters have a built-in or add-on duplexer that allows the unit to simultaneously transmit and receive on the same antenna. The duplexer contains RF components that isolate the transmitter from the receiver. This way the transmitter's power does not damage the receiver, and reflected power doesn't damage the transmitter (if an antenna is damaged). However, if a duplexer is not available, antenna placement is critical to prevent the receiving antenna from taking in energy from the transmitting antenna. This situation is typically resolved by placing the antennas at different heights to minimize this interference, and underground operations may require a duplexer. The minimum distance for separation (both vertical and horizontal) are dependent on the frequency bands used.

Once the antenna configuration is determined, the repeater and antenna are usually positioned to provide the most amount of coverage based on the operating environment. For buildings, it may be placed within the building with an omnidirectional antenna or outside with a directional antenna. Additional considerations are required for multifloor buildings. Antennas are preferably mounted with a line of sight to all repeaters or other two-way radio users. Significant care is required to avoid exceeding RF exposure in confined environments such as tunnels.

Subterranean and indoor applications typically introduce significant radio signal attenuation from heavily reinforced concrete walls, metal construction materials, and shielded or underground infrastructure. Below ground access ways are also problematic, especially sharp 90°- and 180°-turns in stairways as well as bends in subway tunnels. Indoor radio communications may experience multipath propagation and interference. This refers to the reception of two different "paths" of the same signal at a delay. Multipath propagation can be caused by the reflection or refraction of the signal by building construction or line of sight obstructions. Multipath interference can degrade received signal quality, especially in digital radios. These applications require on-site radio coverage testing to replicate the quality and coverage of signals transmitted by the repeater from a given location. For tunnels, the typical approach is to place a directional antenna at one end.

However, this process may require trying several options to find the best antenna location or antenna type to ensure adequate performance of the repeated signal. One potential option for in-building and tunnel operations is connecting the portable repeater system to the Distributed Antenna System (DAS). Some jurisdictions may have mandated access to the DAS equipment.

2.3 RELEVANT STANDARDS AND REGULATIONS

2.3.1 PROJECT P25

Compliance with the Association of Public Safety Communications Officials (APCO) Project 25 (P25) [3] was a requirement for inclusion in this market survey. A suite of standards, P25 (also called APCO-25) was specifically designed for public safety agencies and is continually being updated. The P25 Statement of Requirements (SoR) serves as the basis for P25 standards and provides details on requirements for public safety communications [4]. The DHS Cybersecurity and Infrastructure Security Agency (CISA) also maintains the Statement of Project 25 User Needs (SPUN) which provides an overview of current P25 standards and how they relate to the P25 SoR [1].

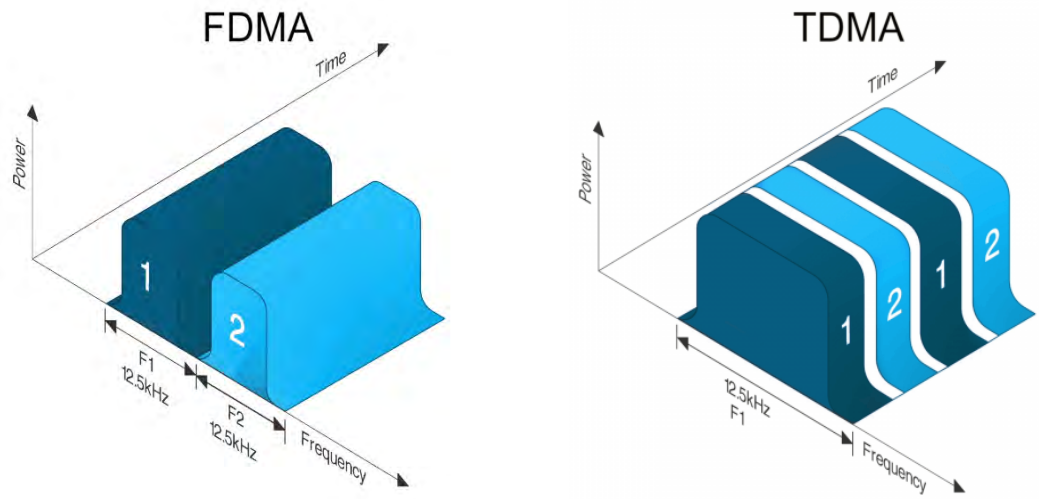

Figure 2-1 Frequency Division Multiple Access and Time Division Multiple Access

Courtesy of Tait Radio Academy

The standards address interoperability issues arising as a result of the transition from analog FM radios to digital radios. With analog radios, interoperability may be achieved by the different agencies simply sharing transmission frequencies. However, aspects of digital radios, such as encryption and trunking systems, make interoperability more complex. P25 is a set of open standards that public safety agencies may use to more easily communicate with other agencies.

P25 radio systems are deployed in two options, called phases. “Phase 1” P25 devices include digital radios that typically have a channel bandwidth of 12.5 kHz. Depending on the system type, it may also allow for analog or mixed transmission modes. Phase 1 P25 devices use frequency-division multiple access (FDMA) as their primary channel access method. FDMA refers to using separate frequencies continuously for the repeater’s transmission (also called “talk-out” or “outbound”) and reception (“talk-in” or “inbound”). Phase 1 P25 devices are commonly compatible with analog radio systems. This allows for a more gradual transition from analog to digital radios which may be a benefit for agencies with smaller budgets allocated to communications infrastructure.

Phase 1 P25 devices are compatible with both conventional and trunked[1] radio communications. The products included in this MSR support conventional Phase 1 P25.

"Phase 2" P25 radios use two-time slot time division multiple access (TDMA) as their primary voice channel access method. A two-time slot TDMA channel is occupied by two groups of users who are each assigned their own time slot. Users transmit one after another in their designated timeslot. TDMA allows for more efficient usage of the available spectrum. Phase 2 P25 devices use a 12.5 kHz channel bandwidth. However, the "effective channel bandwidth" is 6.25 kHz because it is used half the time. Phase 2 TDMA systems are specific to trunked radios. Some radio systems may include a multi-mode operation feature which enables the system to switch between TDMA and FDMA for each channel. If radios are required within the repeater, trunking using Phase 1 P25 and Phase 2 may be possible; agencies should verify compatibility with the vendor for both the radio and the amplifier.

P25 encryption may use several methods. While encryption keys may be manually programmed into devices, conventional and trunked P25 also features an over the air rekeying (OTAR) function. While the OTAR function removes the need for radio maintainers to physically touch the radios, key change coordination becomes complex for interoperability users. Portable repeaters may be capable of repeating conventional OTAR commands.

Other benefits of trunked P25 are priority and preemption. This refers to prioritizing specific users on a designated channel and preventing other users from using the channel for transmissions to try to maintain clear channels for communication without crosstalk. Priority and preemption may be a useful feature for emergency calls such as initial dispatches or requests for additional resources. It should be noted that this feature is only available on trunked radio systems and not on conventional radio systems.

When procuring P25 devices, public safety agencies should prioritize products that have been certified by the DHS P25 Compliance Assessment Program (P25 CAP) [5]. P25 CAP is a voluntary program which ensures that a product was tested at a DHS-recognized laboratory and was found to be compliant with P25. The P25 CAP evaluates devices against P25 standards rather than the P25 SoR. Radios and other devices that have been tested by the P25 CAP program may be eligible for federal grant programs. It should be noted that while many of the repeaters in this report have not been certified by P25 CAP, they are still compatible with handheld radio models that have been certified. Agencies should investigate methods for purchasing in order to ensure grant compliance.

[1] A conventional radio system is one in which the user manually selects channels from frequencies allocated in an agency communications plan. A trunked radio system uses a control channel to automatically assign channels to user groups (also called talkgroups). While conventional radios use a single dedicated channel for each talkgroup, trunked radios use a pool of channels for multiple talkgroups. Trunked radio systems are more complex but offer the advantage of improved system resilience to channel failures and spectrum efficiency.

2.3.2 USE OF GRANT FUNDS FOR CERTAIN TELECOMMUNICATIONS AND VIDEO SURVEILLANCE EQUIPMENT OR SERVICES

The John S. McCain National Defense Authorization Act for Fiscal Year 2019 (NDAA), Pub. L. 115-232, Section 889 (NDAA) prohibits the use of federal funds, including loan and grant[2] funds, to obtain or acquire certain telecommunications technologies manufactured by certain entities or to enter into contracts with entities that use those technologies. The Office of Management and Budget (OMB) published regulations at 2 C.F.R. § 200.216 to clarify the application of the NDAA to the use of federal grant funds to procure or obtain certain telecommunications equipment or services.

Effective August 13, 2020, federal grant recipients and subrecipients (i.e., **non-federal entities**) are prohibited from obligating or expending loan or grant funds to procure or obtain[3] the following "covered telecommunications equipment or services":

- Telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities)
- For the purpose of public safety, security of government facilities, physical security surveillance of critical infrastructure, and other national security purposes, video surveillance and telecommunications equipment produced by:
    - Hytera Communications Corporation
    - Hangzhou Hikvision Digital Technology Company
    - Dahua Technology Company
    - Or any subsidiary or affiliate of such entities
- Other entities identified by the Secretary of Defense

The restriction also applies to systems that use the covered equipment or services as a substantial or essential component, and to subsidiaries or affiliates of those listed above[4]. See https://www.federalregister.gov/d/2020-17468/p-877.

Costs associated with covered equipment and services are "unallowable" for grant funding. Grant recipients are responsible for ensuring funds are used only for allowable costs and would be obligated to refund the government for unallowable costs. The Federal Emergency Management Agency (FEMA) issued FEMA Policy #405-143-1, "Prohibitions on Expending FEMA Award Funds for Covered Telecommunications Equipment or Services (Interim)," for further guidance on the Section 889 prohibitions. Additionally, OMB issued frequently asked questions (FAQs) on the topic.

For **federal** entities, FEMA published interim rules amending the Federal Acquisition Regulation[5].

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[2] This also includes cooperative agreement funds.

[3] Nor may they extend or renew a contract to procure or obtain, or enter into a contract to procure or obtain the covered equipment or services

[4] as well as telecommunications or video surveillance services provided by entities or using equipment described above.

[5] https://www.federalregister.gov/documents/2019/12/13/2019-26579/federal-acquisition-regulation-prohibition-on-contracting-for-certain-telecommunications-and-video and https://www.federalregister.gov/documents/2019/08/13/2019-17201/federal-acquisition-regulation-prohibition-on-contracting-for-certain-telecommunications-and-video

2.3.3 APPLICABLE FEDERAL REGULATIONS

The repeater should be type accepted for the frequency band in operation and meet the requirements in Parts 15 and 90 of Title 47, "Federal Communications Commission" (FCC) of the Code of Federal Regulations, sometimes referred to as the "FCC Rules." Repeater use should follow the frequency license requirements provided by the FCC.

Radio Frequency Devices ,Federal Communications Commission, 47 CFR, §15 [6] contains technical specifications, administrative requirements and other conditions relating to the marketing and operation of radio devices. Specifically this portion of the Code of Federal Regulations lays out rules under which intentional[6], unintentional[7], or incidental[8] radiators may be operated without an individual license[9]. Operators of intentional or unintentional radiators have no right to continue use of any given frequency or power line carrier system and they may not cause harmful interference [7].

Radiators must be constructed according to regulations, in accordance with good engineering design and manufacturing practices, and emanations from the device must be suppressed as much as possible. Operators should consider the proximity and power level of non-Government licensed radio stations and of U.S. Government radio stations when choosing operating frequencies from the set of frequencies the operator is authorized to use [8]. Intentional radiators operated as carrier current systems; devices operated under the provisions of subparts 15.211 "Tunnel Radio Systems," 15.213 "Cable Locating Equipment," and various subparts addressing specific frequency bands (including 15.240 "Operation in the band 433.5-434.5 MHz;" 15.241 "Operation in the band 174-216 MHz;" 15.242 "Operation in the bands 174-216 MHz and 470-668 MHz;" and 15.243 "Operation in the band 890-940 MHz") and devices in which all emissions are at least 40 dB below the limit noted in 15.209 "Radiated Emission Limits [6]" are subject to the Supplier's Declaration of Conformity[10] [9] [10]. Part 15, Subpart C, "Intentional Radiators [11]," includes, but is not limited to, information on certified operating frequency range, antenna requirement, external radio frequency power amplifiers and antenna modifications, restricted bands of operation, conducted limited, and tunnel radio systems.

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[6] A device that intentionally generates or emits radio frequency energy by radiation or induction.
[7] A device that intentionally generates radio frequency energy for use within the device, or that sends radio frequency signals by conduction to associated equipment via connecting wiring, but which is not intended to emit Rf energy by radiation or induction.
[8] A device that generates radio frequency energy during the course of its operation although the device is not intentionally designed to generate or emit radio frequency energy (e.g., mechanical light switches).
[9] Part 15 contains subparts A through H. Because not every subsection pertains to radio repeaters, the descriptions below do not cover all of the subsections. Subsections A through H can be viewed in full, however, at 47 CFR §15.
[10] See also the FCC's webpage on Equipment Authorization Procedures, which discusses how to identify the applicable standard (Certification or Supplier's Declaration of Conformity) based on RF functions: https://www.fcc.gov/general/equipment-authorization-procedures

Private Land Mobile Radio Services, Federal Communications Commission, 47 CFR § 90 [12] regulates the conditions under which radio communications systems may be licensed by non-federal agencies in Subparts B, C and F (or "Public Safety," "Industrial/Business Radio Pool," and "Radiolocation Radio Services[11]"). Part 90 sets forth requirements applicable to the use of certain frequencies or frequency bands, including but not limited to disaster communications bands allocated for federal use, bands for low power use, and restrictions on operation of fixed stations "associated with one or more mobile relay stations [13]."

Subpart B [14] regulates the Public Safety Radio Pool, which covers the licensing of the radio communications of governmental entities and a variety of categories, including but not limited to medical services and rescue organizations. The "Public Safety National Plan" specifies policies and procedures that govern the Public Safety Pool. The 758-769 MHz and 788-799 MHz bands are allocated for use by the First Responder Network Authority to deploy a nationwide public safety broadband network [15]. The principal spectrum resource for the National Plan is the 806-809 MHz and the 851-854 MHz bands at locations farther than 68.4 miles from the U.S.-Mexico border and 87 miles from the U.S.-Canada border [16].

Subpart H governs the assignment of frequencies [17]. Frequencies assigned to land mobile stations are available on a shared basis only and will not be assigned for the exclusive use of any licensee. Failure to cooperate could result in restrictions.

Subpart J, Part 90.247 "Mobile Repeater Stations [18]" states a mobile station authorized to operate on a mobile service frequency above 25 MHz may be used as a mobile repeater to extend the communications range of hand-carried units, subject to certain restrictions.

All intentional emitters require "Part 90 certification [19]." The following radio device specifications must be tested: RF power output, modulation characteristics, occupied bandwidth, spurious emissions at antenna terminals, field strength of spurious radiation, and frequency stability [20]. Once a certification is issued, the user of the equipment must obtain a license to operate the device. The FCC has been authorized by Congress to certify private organizations to act as "frequency coordinators [21]" – persons or groups coordinating frequencies and services of commercial and public frequencies so that the spectrum does not interfere with other users and remains efficient. Public safety agencies should consult frequency coordinators to ensure that their communications are not subjected to interference from other users, to prevent causing interference to other users, and for information on interoperability capabilities with other agencies.

2.3.4 SAFETY AND DURABILITY STANDARDS

The standard most applicable to portable radio repeaters is the National Fire Protection Association (NFPA) 1802 Standard on Two-Way, Portable RF Voice Communications Devices for Use by Emergency Services Personnel in the Hazard Zone [22]. The standard identifies operating environmental parameters and minimum requirements for the design, performance, testing, and certification of portable RF devices intended for use by emergency personnel.

[11] Part 90 contains subparts A to Z. Not all of those subsections pertains to radio repeaters, therefore not every one of them is described herein. The complete text, however, can be viewed at 47 CFR §90.

The purpose of these requirements is to ensure that RF devices can withstand extreme environmental conditions without compromising performance when operating on emergency services communications networks. While NFPA 1802 is intended for handheld mobile radios, it may be applicable to the radios used within some portable repeaters.

In addition to products compliant with NFPA 1802, public safety agencies may also consider products that are certified under TIA-4950 Requirements for Battery-Powered, Portable Land Mobile Radio Applications in Class I, II, III, Division I, Hazardous (Classified) Locations. One such standard referenced within TIA-4950 is UL 913 "Standard for Intrinsically Safe Apparatus and Associated Apparatus for Use in Class I, II, III, Division 1, Hazardous (Classified) Locations [23]." Intrinsic safety is the ability of electrical equipment to be used safely in a specific explosive environment. The UL 913 standard includes details on the protection techniques that limit the amount of electrical and thermal energy available for ignition. The standard also includes requirements for equipment that may interface with intrinsically safe equipment. In order for an overall device to be fully intrinsically safe, all equipment contained within the device must be intrinsically safe. As an example, an intrinisically safe radio used with a non-intrinsically safe battery is no longer intrinsically safe. UL 913 references the NFPA National Electrical Code [24] for the definition of a hazardous environment as one with a presence of flammable gases (such as acetylene, hydrogen, ethylene or propane) or ignitable dusts or fibers (such as magnesium, carbon, charcoal, flour, grain, wood, plastic, cotton lint, flax, and rayon).

Similar intrinsic safety standards include the International Electrotechnical Commission (IEC) 60079 Series [25], a multi-part international standard titled "Explosive Atmospheres Standards," and the Atmosphères Explosible (ATEX) standard [26], which is universally accepted in the European Union.

Portable radio repeaters may be compliant with the U.S. Military Standard MIL-STD-810, "Environmental Engineering Considerations and Laboratory Tests [27]," which is maintained and enforced by the Department of Defense. The standard includes guidance on laboratory test methods used to ensure a product's ability to withstand extreme conditions such as high temperature, temperature shock, contamination by fluids, explosive atmospheres, acceleration and vibration. Results of this testing may assist in learning the effects of stress factors and help determine if equipment being purchased will be reliable and durable for its use cases. The most current version of the standard is MIL-STD-810H which was published in 2019 [27]. However, since it is still relatively new, compliance with the previous version, MIL-STD-810G (published in 2008) [28], is generally considered sufficient for operational usage. Many of the repeaters in this Market Survey Report were developed prior to the publishing of MIL-STD-810H and are therefore only tested to MIL-STD-810G. More information on MIL-STD-810G test methods is included in Appendix A.

Public safety agencies may also consider ingress protection (IP) ratings when procuring a radio repeater. IP ratings are defined by the IEC International Standard 60529, entitled "Degrees of Protection Provided by Enclosures (IP Code) [29]." An IP rating consists of two digits. The first digit represents the degree of solid IP and ranges from zero to six (0-6). The second digit represents the degree of liquid IP and ranges from zero to nine (0-9). Most products included in this market survey report cite an IP rating of IP67, which means that the product is dust tight and can withstand immersion in liquid of up to one meter [30].

It should be noted that the repeater may have a different IP rating than the enclosure. If the repeater has a lower rating than the enclosure, first responders should confirm that the product can be operated with the enclosure closed if necessary. More information on IP ratings is included in Appendix B.

Some products may list a National Electrical Manufacturer's Association rating or enclosure type rather than an IP rating. These types are defined in the NEMA 250, "Standard Enclosures for Electrical Equipment (1,000 V Maximum) [31]." The standard identifies several types of electrical enclosures that may be used in hazardous and non-hazardous environments, as defined by the NFPA 70 standard [24]. Each enclosure type is defined with respect to IP and intrinsic safety. For example, a product with a NEMA rating of six is submersible, watertight, dust tight, and ice and sleet resistant and is intended for general purpose usage indoor and outdoor non-hazardous environments. This corresponds most to an IP rating of IP67 [32]. More information on NEMA enclosure ratings is included in Appendix B.

2.4 EMERGING TECHNOLOGIES

The acceptance and proliferation of advanced cellular telephone technology and projected advancements in device human interface development has the potential to add additional communication devices that repeater technology could support or even displace the need for repeater technology in the years to come.

2.4.1 5G BROADBAND

With the evolving 5G broadband cellphone networks expected to be fully implemented by 2035, emergency responders will see an increase in radio repeater technology incorporating this global network upgrade. The next generation of mobile networks is expected to include capabilities for enhanced mobile broadband, mission critical communications, and the Internet of Things (IoT). The biggest impact for first responders will be that mission-critical communications will have dramatically lower latency, enabling faster communication. For first responders utilizing cellular networks, downlink peak data rates of up to 7.5 Gbps on broadband cellular networks. While specific frequencies are dependent on the service provider, 5G networks will operate in the frequency band from 450 MHz to 6 GHz (which overlaps with current public safety networks and LTE networks) and the frequency band from 24.25 GHz to 52.6 GHz [33]. Future 5G installations are projected to have many small cell implementations to improve coverage for high-data-rate communications and incorporate low UHF frequency bands that have the capability for longer range communications. Power output from cellular devices will be much lower than P25 radios, however. Bridging current radio repeater technology to the 5G networks could greatly expand radio system coverage.

2.4.2 MESH NETWORKING

Mesh networking has great promise for use in radio networks. A mesh network is a local network where devices can connect directly, dynamically and non-hierarchically to as many other devices as possible to relay information in a simplex or duplex manner. Coupling mesh networks with 5G capabilities could significantly improve the networks where direct line of site is limited. The ability to push out information in a constantly changing node topology would be very beneficial for first responders who work at variable locations with constant challenges arising.

Ongoing research is being done on this capability, with DHS previously exploring the implementation of mesh network-enabled radios with emergency response agencies such as the New York Police Department (NYPD) [34]. With the implementation of mesh networks coupled with radio repeater technology, extension and transmission of critical communication could be greatly extended.

3.0 PRODUCT INFORMATION

This section provides information on 20 portable radio repeaters for indoor and subterranean environments, but prices listed may not include the necessary portable or mobile radios within the repeater required for functionality. Product prices range from $3,700 to $51,000, while price information on four of the repeaters is available only as a quote from the vendor. All products in this report are human-portable solutions, contained within a protective enclosure, deployable as needed, and compliant with the P25 radio standard. Table 3-1 provides general product characteristics and specifications. Product information presented in this section was obtained directly from manufacturers, vendors, and their websites. The information has not been independently verified by the SAVER Program.

Product information in Table 3-1 is defined as follows, listed in column order:

MSRP refers to the manufacturer's suggested retail price of the product in U.S. dollars. An asterisk(*) indicates that pricing information is available only by quote from the vendor. A dagger (†) indicates that the price may not represent the total cost to operate the device.

TX/RX refers to whether the repeater uses self-contained transmitters and receivers, embedded handheld radios or embedded dashmount radios.

Frequencies refers to the frequency bands and, if provided, the specific frequencies the repeater operates on in megahertz (MHz). This specification may be dependent upon the user's radio, rather than the repeater. While all the products in this report are compatible with P25 radios, some repeaters may also communicate on non-P25 frequencies.

RF power refers to the maximum RF transmission power of the repeater in watts (W). Transmission power may be adjustable and is dependent on cable loss along with antenna performance. This specification may be dependent upon the user's tactical radio, rather than the repeater. RF power may also be dependent on frequency band.

Receiver sensitivity refers to the minimum signal strength in decibel-milliwatts (dBm) that the repeater's receiver can detect. This specification may be dependent on operating mode (i.e., analog or digital).

Size refers to the outer dimensions of the repeater in inches (”), given as length by depth by height.

Weight refers to the maximum physical weight of the repeater in pounds (lb). Weight may be dependent on the configuration of the repeater.

Power Sources refers to whether the repeater can be powered by external AC and/or DC sources and internal batteries. Unless otherwise specified, “DC” implies 12V. More information on available options and specifications is included in the subsequent product descriptions.

Additional Features refers to any characteristics of a repeater that provide additional functionality, such as software-defined radio interface for configuration and monitoring, network interfaces (including cellular LTE and SATCOM), modular construction for improved portability, command post/stationary mode option (i.e., users can communicate via an optional handset on the repeater itself rather than through a separate handheld mobile radio), and cross-band interoperability.

Table 3-1 Product Comparison Matrix

Manufacturer and Product	RX/TX	MSRP	Frequencies	RF Power	Receiver Sensitivity	Size (L x D x H)	Weight	Power Sources	Additional Features
ABP ABP-RPT-MBITR-3	Embedded handheld radios	*	VHF/UHF: 30-512 MHz	50 W	-116 dBm	19.3” x 15.3” x 7.5”	30 lb (without radios)	External AC, DC	SATCOM interface, optional command post radio speaker and headset
ABP ABP-RPT-152-3	Embedded handheld radios	*	VHF/UHF: 30-512 MHz	50 W	-116 dBm	19.3” x 15.3” x 7.5”	30 lb (without radios)	External AC, DC	SATCOM interface, optional command post radio speaker and headset
BK Technologies Rapid Deployment Portable Repeater	Embedded handheld radios	$3,800†	VHF UHF 700/800‡	‡	‡	16.2” x 12.7” x 6.6”	17 lb	Internal battery; external AC, DC, battery	Radio-specific interface kits, sold separately
Catalyst Communications Mobile Incident Command	Embedded dashmount radios	*	§	§	§	24” x 17” x 14”	§	Internal battery; external AC, DC or battery	Software-defined radio interface Separate cellular LTE network interface available
Cell Antenna Wireless CA-BRAVO-708090	Self-contained	$9,000	700/800	0.5 W	N/A	18” x 12” x 24”	56 lb	External AC, DC; internal backup battery	
Codan Communications ET-4 Ruggedized System	Self-contained	$18,000	VHF UHF 700/800/900	8W (VHF, UHF) 3 W (700/800/900)	-116 dBm	25” x 20” x 11.8”	50 lb	Internal battery; external AC, DC	
Codan Communications ET-5 Tactical Repeater	Self-contained	$12,500	VHF UHF 700/800 MHz	8W (VHF, UHF) 3 W (700/800)	-116 dBm	14.7” x 11” x 6.5”	20 lb	Internal battery	

Manufacturer and Product	RX/TX	MSRP	Frequencies	RF Power	Receiver Sensitivity	Size (L x D x H)	Weight	Power Sources	Additional Features
Codan Communications ET-6 Repeater and Base Station	Self-contained	$12,700	VHF: 144-174 MHz UHF: 380-470 MHz 700/800: 768-869 MHz	30 W (VHF, UHF) 3 W (700/800)	-116 dBm	18.2" x 13.4" x 6.7"	28 lb	External AC, DC	Antenna relay
Codan Communications Stratus P25/LTE Transportable Repeater/Base Station	Self-contained	$29,500	VHF: 136-174 MHz UHF: 380-520 MHz 700/800/900: 768-869 MHz 896-960 MHz	30 W (VHF, UHF) 25 W (700/800) 3 W (900)	-116 dBm	15.2" x 9.2 x 7.3"	32 lb	Internal battery	Optional cellular 3G/LTE network interface, DFSI
Etherstack SFFR-6 Tactical Repeater "GoBox"	Self-contained	$25,000	VHF: 136-174 MHz UHF: 380-520 MHz	15 W	-117 dBm	8.5" x 10.2" x 7.8"	20 lb	Internal battery, external AC, DC	Duplexer bypass, DFSI
K.R. NIDA PTR-220	Embedded dashmount radios	$4,500†	700/800/900	50 W‡	‡	19.7" x 12" x 19"	60 lb	Internal battery; external AC/DC	
Kutta Radios Kutta Link KLR200	Embedded dashmount radios	$20,000†	UHF: 450-520 MHz	45 W	-119 dBm	16.2" x 12.7" x 6.6"	20 lb	Internal battery, external AC/DC	45 kHz transmission, Command post radio headset

Manufacturer and Product	RX/TX	MSRP	Frequencies	RF Power	Receiver Sensitivity	Size (L x D x H)	Weight	Power Sources	Additional Features
Motorola Solutions PDR8000 Portable Digital Repeater	Self-contained	$16,000	VHF: 136-174 MHz UHF: 380-430 MHz 450-470 MHz 700/800: 764-776 MHz 794-806 MHz 806-824 MHz 851-869 MHz	20W (VHF) 19W (UHF) 16W (700) 17W (800)	-115 dBm	19.2” x 15.2” x 7.3”	28 lb	Internal battery; externa l DC	Optional booster pack (50W across all bands), Optional duplexer, Optional cross-band interoperability
RCA Communications RCA RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater	Self-contained	*	VHF: 136-174 MHz UHF: 335-400 MHz 400-480 MHz 440-520 MHz	25 W	-117 dBm	18.5” x 14.1” x 6.9”	20 lb	External AC, DC	VHF/UHF cross-band interoperability
SIMOCO Wireless Solutions SRB250 P25 Rapid Deployment Repeater	Self-contained	$9,000†	VHF: 136-174 MHz UHF: 400-480 MHz 440-520 MHz	25 W	-117 dBm	19.8” x 15.8” x 6.5”	32 lb	Internal battery; external AC/DC, battery	
Tait Radios TB7300 Transportable Repeater	Self-contained	$15,000	VHF: 148-174 MHz UHF: 400-470 MHz	30 W (VHF) 25W (UHF)	-120 dBm	18” x 21” x 9”	50 lb	Internal battery, external AC, DC	Software defined radio interface
Thales TRC6730 20-Watt Tactical Repeater	Self-contained	$46,000†	VHF/UHF: 30-512 MHz	20 W	-115 dBm	24.6” x 19.7” x 11.7”	82 lb	External AC or DC	Base station

Manufacturer and Product	RX/TX	MSRP	Frequencies	RF Power	Receiver Sensitivity	Size (L x D x H)	Weight	Power Sources	Additional Features
Thales TRC6730 50-Watt Tactical Repeater	Self-contained	$51,000†	VHF: 30-88 MHz VHF/UHF: 88-512 MHz	50 W (VHF) 20 W (VHF/UHF)	-115 dBm	24.9" x 23.7" x 13.1"	107 lb	External AC or DC	Base station
Van Cleve ECHO 8	Self-contained	$7,000	VHF: 150-174 MHz	2 W	-121 dBm	10.8" x 9.8" x 5"	12 lb	Internal battery; external DC	
Wireless Innovation Portable Radio Repeater Rapid Deployment Kit	Self-contained	$16,000	VHF: 66-88 MHz 136-174 MHz UHF: 350-400 MHz 400-470 MHz 450-527 MHz 800/900: 806-941 MHz	25 W	-121 dBm	25" x 20" x 12"	65 lb	Internal battery; external AC	Optional SATCOM interface Optional command post radio headset

Notes:
* - available by quote only
† – indicates price may not reflect total cost of device operation
‡ – dependent on radio
§ – see Table 3-2
N/A – not available (information was not provided by the vendor)

3.1 ABP, ABP-RPT-MBITR-3 DUAL BASE STATION/REPEATER

The ABP-RPT-MBITR-3 operates on the UHF SATCOM, VHF line of sight (LOS) and 30-512 MHz frequency bands with an output power of 50 watts. The ABP-RPT-MBITR-3 is powered by 85-270 V ac/47-440 Hz or 9-36V dc. It has worldwide input power (including aircraft power). The repeater is compatible with the P25 radio standard using the Harris AN/PRC-152A or AN/PRC-163. The repeater has a receiver sensitivity of -116 dBm at 12 dB signal-to-noise and distortion (SINAD) ratio.

Figure 3-1 ABP-RPT-MBITR-3 Dual Base Station/Repeater

Courtesy of ABP

This item has a triple purpose capability: it can be employed as a dual base station, repeater, or re-transmitter. It has two auxiliary 26 V dc/1 A outputs for ABS's High Efficiency Amplified Speakers™ (optional) or other external audio equipment. The optional High Efficiency Amplified Speakers allow for monitoring of voice traffic with automatic level control and supports local operation when the repeater is used as a base station. A handset can be connected to the optional speakers so that the repeater can also be used as a command post radio. The repeater can also interface with SATCOM radios via a built-in low-noise amplifier (LNA).

The channels, bandwidth, and duplex frequency separation are dependent on the radios being used. The duplexer frequency separation is typically around 10 MHz for MBITRs.

The ABP-RPT-MBITR-3 has exterior dimensions of 19.25"L x 15.3"D x 7.5"H and weighs 30 lb (without transceivers). The case can be locked with a padlock and may be checked on a commercial airline. It comes with one six foot long AC cable and one six foot long DC cable with alligator clips. Radios and coaxial cables for antennas are not included. The case has storage space for AC and DC cables, coaxial cables, radios, handsets, and antennas. This portable repeater is outfitted with protective elements, including a robust composite case with quick lock latches and an internal gasket that is watertight, airtight, sand proof and dustproof (corresponding to an IP67 rating). The ABP-RPT-MBITR-3 has an operating temperature range of -40 °F to 158 °F.

No user intervention is required after setup. Calibration for amplifiers can be performed if other than normal operations are expected.

Vendor outreach is required for pricing quotes. Purchase of the repeater includes a three-year warranty and a detailed manual. This product is also available for purchase through a GSA schedule. Extended warranties and advanced trainings are available for an additional cost. Customer support can be contacted five days a week from 8:00 a.m. to 5:00 p.m. Eastern time at 301-977-5570 or info@abp.com.

3.2 ABP, ABP-RPT-152-3 DUAL BASE STATION/REPEATER

The ABP-RPT-152-3 Dual Base Station/Repeater operates on UHF SATCOM and VHS LOS frequency bands. The frequency band is 30-512 MHz with an output power of 50 watts. The ABP-RPT-152-3 is powered by worldwide input power (including aircraft power): 85-270 V ac/47-440 Hz or 9-36 V c. The repeater retransmits signals via two L3Harris AN/PRC-152 or AN/PRC-163 radios. The repeater supports communications with analog, digital and P25 radios. It should be noted that due to the usage of the L3Harris radio, the repeater is only compatible with P25 radios when operating at 512-520 and 762-870 MHz. It is typically deployed in either a base station or repeater configuration. The repeater has a receiver sensitivity of -116 dBm at 12 dB SINAD.

The channels, bandwidth, and the duplex frequency separation that the ABT-RPT-152-3 can support vary based on the radios being used. The repeater can also interface with SATCOM radios via a built-in LNA.

Figure 3-2 ABP-RPT-152-3 Dual Base Station/Repeater

Courtesy of ABP

The ABP-RPT-152-3 Dual Base Station/Repeater has exterior dimensions of 19.25"L x 15.3"D x 7.5"H and weighs 30 lb (without transceivers). It also has storage space for AC and DC cables, coaxial cables, government furnished equipment (GFE) radios, handsets, and antennas. This portable repeater is outfitted with protective elements, including a robust composite case with quick lock latches and an internal gasket that is water-, sand-, and dustproof as well as airtight (corresponding to an IP67 rating). The repeater has an operating temperature range of -40 °F to 158 °F.

Calibration for amplifiers can be performed if operations other than normal are expected.

Vendor outreach is required for pricing quotes. Purchase of the ABP-RPT-152-3 Dual Base Station/Repeater includes a detailed user's manual. This product is also available for purchase through a GSA schedule. Customer support is available five days a week, 8:00 a.m. to 5:00 p.m. Eastern time and can be reached at 301-977-5570 or info@abp.com.

3.3 BK TECHNOLOGIES, RAPID DEPLOYMENT PORTABLE REPEATER

The Bendix King Rapid Deployment Portable Repeater (RDPR-00UM) requires two portable radios and a radio interface kit (RIK) to be installed in the repeater. One portable radio serves as a receiver while the other serves as a transmitter. Different RIKs are available for various radio models and are sold separately from the repeater.

Many specifications, such as frequency, transmission power, receiver sensitivity and encryption methods of the RDPR-00UM are dependent on the portable radios used. The repeater can be used with HF, VHF, UHF and 700/800 MHz radios. The repeater supports both analog and digital radios, is compatible with all portable radio models, and supports the P25 radio standard. The RDPR retransmits encrypted portable radio voice transmissions and is compatible with AES, DES, and ADP encryption methods. A high-power version of the repeater, which transmits at 45 W, is available.

Transmission power of the standard model of the repeater is dependent on the handheld mobile radios that are embedded.

The portable repeater supports one channel at a time with its channel bandwidth dependent on the portable radio being used. The RDPR-00UM has a duplexer frequency separation of 4.5 MHz to 9.5 MHz and supports trunked radio applications. RIKs that can be installed in the repeater allow for cross-mode (analog and digital), cross-band, and cross-protocol (conventional and trunked) interoperable communications.

The RDPR-00UM is powered by an internal 7 Ah sealed lead-acid battery. The repeater can also be powered by external sources including a 110-220-V ac-dc power adapter, foldable 20-, 60-, or 90-watt solar panels, and an external 40 Ah lithium ion battery connected via USB or lighter ports.

Figure 3-3 Rapid Deployment Portable Repeater

Courtesy of BK Technologies

The RDPR-00UM has exterior dimensions of 16.2"L x 12.7"D x 6.6"H and weighs 17 lb. The RDPR-00UM has an operating temperature range of -22 °F to 140 °F. This portable repeater is embedded within a Pelican case with a handle for easy transporting. A larger accessory case available for purchase includes storage spaces for antennas and foldable solar panels. A separate incident command kit also includes storage space for a cache of 12 portable radios.

The RDPR-00UM carries a UL listing, has been tested to MIL-STD-810G, and has an IP rating of IP58.

Maintenance and calibration are recommended annually and can be conducted in-house or by BK Technologies. Software and firmware on the repeater are updated with the installation of the RIK. After the initial installation of the RIK in the repeater enclosure, updates are dependent on the portable radios.

The RDPR-00UM has an MSRP of $3,787 that includes a two-year warranty, initial training, and access to print and electronic operator's manuals. This cost does not include the RIK or antennas. This product is also available for purchase through a GSA schedule. Customer support is available via phone, Monday to Friday from 9:00 a.m. to 5:00 p.m. Eastern time. Off-hours customer support can also be arranged when purchasing.

3.4 CATALYST COMMUNICATIONS, MOBILE INCIDENT COMMAND/DIGITAL VEHICULAR REPEATER SYSTEM

The Catalyst Communications Technologies Mobile Incident Command/Digital Vehicular Repeater System (DVRS) is available in three variants. The three variants of this product are based on whether radios from Kenwood (Fire™), Bendix King (Fire-BK™), or Harris (Ice™) are used (see Table 3-2). The repeater operates in the UHF, VHF, 700 and 800 MHz, marine, aviation and special military frequency bands with an output power between 15 to 110 W depending on which radio is used. Each variant has multiple radio configurations depending on the user's needs. The Mobile Incident Command/DVRS is powered by a 14 V dc internal or external battery or an optional 110 V ac supply.

All variants support both analog and digital radios. All variants are compatible with radios within the variant's product line, support P25 and use AES encryption (with details dependent on the specific variant). The portable repeater can support multiple channels. Its channel bandwidth, however, is dependent on the radio used. The Mobile Incident Command/DVRS does not provide a duplexer, but all variants support trunked radio applications.

A software-defined radio interface can be used with the repeater to configure mobile radios and to monitor and record radio traffic and metadata. The software interface is typically installed on a laptop computer for portability. The repeater is also capable of communicating with Catalyst's IntelliLink Interworking gateway. While the IntelliLink is not integrated into the portable repeater, it provides an interface with LTE networks.

The Mobile Incident Command/DVRS has exterior dimensions of 24"L x 17"D x 14"H. Weight varies by variant and the number of radios embedded in the carrying case. Up to three radios of the same model can be embedded in the case. Fire™ ranges from 48.5 to 55.5 lb, Fire-BK™ from 52.5 to 67.5 lb and Ice™ from 70.9 to 84.4 lb. This portable repeater is outfitted with protective elements, including a ruggedized water-resistant case with handles and wheels, and has optional vehicle mounting brackets. The Mobile Incident Command/DVRS has an operating temperature range of -22 °F to 140 °F.

Maintenance is recommended annually or dependent on the maintenance level coverage of the end user. Maintenance tasks can be conducted in-house (e.g., maintaining Windows software on the laptop computer and performing radio checks), by an approved service provider (e.g., assisting in maintenance and calibration), or by the manufacturer (for complete service). Maintenance costs vary. Depending on the maintenance level coverage purchased by the end user, software and firmware updates are provided and are installed with manufacturer-provided remote assistance. The software can be loaded onto a USB and/or sent as a file to the end user.

Figure 3-4 Mobile Incident Command Repeater System Fire (left) and Ice (right)

Courtesy of Catalyst Communications

The cost of the Mobile Incident Command/DVRS is proprietary and confidential; it includes training with access to print or electronic product manuals as well as videos shared on the internet. Training is not deemed necessary but is available in the form of videos, documents, and presentations. This product is not available for purchase through a GSA schedule. Extended warranties and further trainings are available for an additional cost that is proprietary and confidential. Customer support is available Monday through Friday, 9:00 a.m. to 5:00 p.m. Eastern time through phone and email communication. Customized care plans are available outside of these hours.

Table 3-2 Mobile Incident Command/Digital Vehicular Repeater System Variants

Repeater Variant	Model No. of Integrated Radio	Frequency (MHz)	Power (W)	Receiver Sensitivity (dBm)*	Maximum Channels	Channel Bandwidth (kHz)	Radio Configuration (lb)		
							Single-Weight	Dual-Weight	Triple-Weight
Fire (compatible with Kenwood mobile radios)	NX5700	136-174	5-50	-119	4,000	6.25, 12.5	48.5	52	55.5
	NX5800	380-470, 450-520	5-45	-119	4,000	6.25, 12.5	48.5	52	55.5
	NX5900	TX: 763-776, 793-806, 806-825, 851-870 RX: 763-776, 851-870	700 MHz: 2-30 800 MHz: 2-35	-119	4,000	6.25, 12.5	48.5	52	55.5
Fire-BK (compatible with Bendix King mobile radios)	KNG-M150	136-174	10-50 or 25-100	-121	5,000	12.5, 25, 30	52.5	60	67.5
	KNG-M400	380-470	10- 50	-119	5,000	12.5, 25, 30	52.5	60	67.5
	KNG-M500	440-520	10- 50	-119	5,000	12.5, 25, 30	52.5	60	67.5
	KNG-M800	763-776, 793-806, 806-524, 851-870	10-30 or 10-35	-119	5,000	12.5, 25, 30	52.5	60	67.5
Ice (compatible with L3 Harris mobile radios)	XG-75M VHF	136-174	8-50 and 50-110	-119	1,024	12.5, 20, 25	70.9	76.8	82.7
	XG-75M UHF	330-380 or 378-430 478-430 or 440-512	8-50	-119	1,024	12.5, 20, 25	70.9	76.8	82.7
	XG-75M 700/800	764-870	700 MHz: 30 800 MHz: 35	-119	1,024	12.5, 20, 25	70.9	76.8	82.7
	XG-100M	VHF Low: 33-48 VHF: 136-174 UHF: 380-520 700/800: 762-870	VHF: 5-50 UHF: 5-50 700: 2-30 800: 2-35	VHF Low: -121.5 VHF: -122.1 UHF: -121.8 700/800: -121.2	1,250	12.5, 20, 25	71.45	77.9	84.35

Notes:
*Receiver sensitivity values are relative to 12 dB SINAD.

3.5 CELL ANTENNA WIRELESS, CA-BRAVO-7080 RAPID DEPLOYMENT DUAL BAND PUBLIC SAFETY EMERGENCY REPEATER SYSTEM

The Cell Antenna Wireless CA-BRAVO-7080 Rapid Deployment Dual Band Public Safety Emergency Repeater System operates on the 700/800 MHz public safety frequency band. The repeater has an RF output power of 27 dBm (approximately 0.5 watts). The CA-BRAVO-7080 also includes automatic gain control and an automatic shutdown function to ensure compliant operations with existing communications infrastructure.

The repeater can be powered by an external 12 V dc power source or a 110 V ac power source. An internal lithium iron phosphate ($LiFEPO_4$) battery provides emergency power if the external power source fails. A fully charged battery lasts an estimated six hours. An upgraded battery with an estimated life of 12 hours is available for purchase. The CA-BRAVO-7080 is compatible with all analog and digital radio models and all encryption methods. The product is compliant with the P25 radio standard.

Figure 3-5 CA-BRAVO-7080
Courtesy of Cell Antenna

The CA-BRAVO-7080 is enclosed within a Pelican case with outer dimensions of 18"L x 12"D x 24"H. The enclosure is wheeled and includes a handle for portability. A power switch and an LMR-240 coaxial antenna connector developed by Times Microwave Systems are built into the enclosure. Two flexible, omnidirectional antennas and a 100-foot flame-retardant LMR-240 cable are included with the repeater for configurability in repeater and antenna deployment. The total weight of the repeater and the enclosure is 56 lb. While this repeater is over the weight limit used to define this survey's scope (section 1.0), the enclosure is equipped with wheels to increase ease of portability. The repeater has an operating temperature range of 0 ˚F to 120 ˚F.

The CA-BRAVO-7080 has an MSRP of $9,000 that includes a two-year warranty and operator's manual.

3.6 CODAN COMMUNICATIONS, ET-4 RUGGEDIZED REPEATER

The Codan ET-4 Ruggedized Repeater operates on VHF (with a transmission power of 0.5–8W or 20–30 W), UHF (0.5–8W or 20–30 W), 700 (0.5–3 W), 800 (0.5–3 W), and 900 MHz (0.5–3 W) frequencies, with power output varying based on the frequency band. The ET-4 is powered by rechargeable sealed lead-acid batteries, supports analog and digital radios, is compatible with P25 radios, and can use AES-256 encryption. The repeater has a receiver sensitivity of -116 dBm at 5% bit error rate (BER) and 12 dB SINAD in the 700, 800 and 900 MHz band range.

The ET-4 Ruggedized Repeater is embedded within an impact resistant polyethylene case that can house the MT-4E series base station/repeater equipment, as well as an optional backup battery, duplexer and accessories. The wheeled case is waterproof and can be transported by one person. The ET-4 has exterior dimensions of 25”L x 20”D x 11.75”H and weighs 50 lb. This portable repeater is outfitted with protective elements, including the rugged storage container and includes a polyurethane brief case which allows for stowing accessories. The ET-4 has an operating temperature range of -30 °F to 140 ˚F.

Figure 3-6 ET-4 Ruggedized Repeater
Courtesy of Codan Communications

The ET-4 has an IP65 rating and has been tested to MIL-STD-810G. The product is also compliant with the IEC 62368-1 safety standard[12] [35].

The system costs $17,777 and includes a 10.5 Ah battery. Final pricing will depend upon the chosen configuration, accessories and warranty options. Customizable training packages are available, and cost depends on the number of students and type of training needed. A training course is offered in North America at the customer’s site for up to ten students at an additional charge. Electronic product documentation includes specification sheets and comparison charts. Training resources and documentation can be found on the Codan Communications website.

3.7 CODAN COMMUNICATIONS, ET-5 TACTICAL REPEATER

Codan’s ET-5 Tactical Repeater provides a small footprint for transportable P25 repeater supporting transparent encryption in VHF/UHF, 700 and 800MHz bands. The repeater has a maximum transmission power of 8 watts in VHF/UHF frequencies and 3W in 700/800 frequencies. It operates with standard alkaline D cell batteries available everywhere or a rechargeable lead-acid battery. The ET-5 supports end-to-end encryption across an entire communications network. The ET-5 operates on the VHF/UHF, 700 and 800 MHz bands with 4.5, 30 and 45 MHz duplexer separation respectively. The repeater has a receiver sensitivity of -116 dBm at 5% BER and 12 dB SINAD.

Figure 3-7 ET-5 Tactical Repeater
Courtesy of Codan Communications

The ET-5 measures 14.7”L x 11”D x 6.5”H and weighs 20 lb. It is designed to be easy to carry. Screw-on cover casings protect the connectors during transport. The ET-5 has an operating temperature range of -30 °F to 140 °F. The ET-5 has an IP65 ingress protection rating and has been tested to MIL-STD-810G. The product is also compliant with the EN 62368-1 safety standard [35].

[12] The IEC 62368-1:2018 standard is titled “Audio/video, information and communication technology equipment – Part 1: Safety requirements”. The standard provides details on the application of safety measures against injury and fire that may result from the use of energy sources for electrical and electronic equipment.

The ET5 is designed to only require minor calibration or service. Maintenance is available by the manufacturer with support available within 24 hours of request. Diagnostic testing can be done in-house. This testing may determine that full re-calibration is needed. In this case, the repeater must be returned to the manufacturer for service.

The Codan ET5 Tactical Repeater costs $12,497 and includes a 10.5 Ah battery, a duplexer, and a black suitcase. Final pricing will depend upon the selected configuration and warranty options. Customizable training packages are available, and cost is driven by the number of students and type of training needed. Electronic product documentation includes specification sheets and comparison charts. Training resources and documentation can be found on the Codan Communications website.

3.8 CODAN COMMUNICATIONS, ET-6 REPEATER AND BASE STATION

Codan's ET-6 Tactical Repeater is a deployable P25 repeater supporting encryption in VHF or UHF bands. The ET-6 can support up to 16 channels in VHF (144-174 MHz), UHF (380-470 MHz) and 768-869 MHz. The repeater has a maximum RF transmission power of 30 watts for VHF and UHF frequencies and 3 watts for 700/800 MHz. The ET-6 also supports end-to-end encryption across a communications network.

Controls include speaker on/off and volume, transmitter (TX)/receiver (RX) channel selector switch, encryption enable/disable switch, and "clear keys" button. The auxiliary connector provides access to balanced audio with TX and RX activity LEDs. The repeater has a receiver sensitivity of -116 dBm at 5% BER and 12 dB SINAD.

Figure 3-8 ET-6 Repeater

Courtesy of Codan Communications

The ET-6 has exterior dimensions of 18.2"L x 13.4"D x 6.7"H and weighs 28 lb. This portable repeater includes protective elements, including the Pelican case, ac and dc power cables, and screw-on cover casings to protect the connectors during transport. The ET-6 has an operating temperature range of -30 °F to 140 °F, and can be operated while closed.

The ET-6 has an IP65 rating and has been tested to MIL-STD-810G. The product is also compliant with the EN 62368-1 safety standard [35].

The ET-6 is designed to only require minor calibration or service. Maintenance is available by the manufacturer within 24 hours of request. Diagnostic testing can be done in-house. This testing may determine that full re-calibration is needed. In this case, the repeater must be returned to the manufacturer for service.

The Codan ET-6 Tactical Repeater costs $12,720 and includes a 35 Ah battery, a duplexer, and black suitcase. Final pricing depends upon the selected configuration and warranty options. Customizable training packages are available; training costs are driven by the number of students and type of training needed. Electronic product documentation includes specification sheets and comparison charts. Training resources and documentation can be found on the Codan Communications website.

3.9 CODAN COMMUNICATIONS, STRATUS P25/LTE TRANSPORTABLE REPEATER/BASE STATION

Codan's Stratus is a deployable P25/LTE system that uses cellular technologies to provide secure mobile voice networks. Using its Universal Interface Card (UIC) and LTE modem, it can link instantaneously into established networks or create a new communications network without requiring a hard-wired Ethernet connection. The Stratus supports the DSFI standard. The Stratus can operate in analog, P25, mixed mode, in the 136-174 MHz, 380-520 MHz, 768-869 MHz, and 896-960 MHz ranges. The repeater has a maximum RF transmission power of 30 watts (VHF/UHF), 25W (700/800), and 3W (900 MHz). The repeater has a receiver sensitivity of -116 dBm at 5% BER and 12 dB SINAD in the 700, 800 and 900 Mhz band range.

Figure 3-9 Codan Stratus
Courtesy of Codan Communications

The Stratus can support up to 32 channels. The Stratus P25 repeaters support end-to-end encryption across an entire communications network. The Stratus transportable repeater allows for the quick swapping of tactical duplexers for multi-channel operation on a single antenna. An optional polypropylene tactical case is available for transporting up to three duplexers.

The Stratus has exterior dimensions of 15.2"L x 9.2"D x 7.3"H and weighs 32 lb. This portable repeater is outfitted with protective elements, including a Pelican case and screw-on cover casings that protect the connectors during transport.

The Stratus has an operating temperature range of -40 °F to 140 °F. The Stratus is capable of operations with the case closed. The Stratus has an IP65 rating and has been tested to MIL-STD-810G. The product is also compliant with the EN 62368-1 safety standard [35].

The Stratus is designed to require only minor calibration or service. Maintenance is available by the manufacturer with support available within 24 hours of request. Diagnostic testing can be done in-house. This testing may determine that full re-calibration is needed. In this case, the repeater must be returned to the manufacturer for service.

The Codan Stratus Tactical Repeater costs $29,500 and includes a duplexer and black suitcase. Final pricing depends upon the selected configuration and warranty options. Customizable training packages are available, the costs of which are driven by the number of students and type of training needed. Electronic product documentation includes specification sheets and comparison charts. Training resources and documentation can be found on the Codan Communications website.

3.10 ETHERSTACK, SFFR-6 TACTICAL REPEATER "GOBOX"

The Etherstack GoBox Transportable Repeater (model number SFFR-6) operates on VHF (136–174 MHz) or UHF (380–520 MHz) frequencies with 1–15 watts with the included duplexer or 27W with an optional duplexer bypass. The GoBox Transportable Repeater can be powered by 100–250 V ac, 9-24 V dc or dual internal hot-swappable lithium ion 11.25 V 8850 mAh batteries. It supports analog and digital radios, is compatible with all P25 CAP compliant radios, and uses all Telecommunications Industry Association (TIA) compliant encryption methods. It should be noted that while the repeater is compatible with P25 CAP radios, the repeater itself has not been certified by the program. The repeater has a receiver sensitivity of -117 dBm.

Figure 3-10 Etherstack GoBox
Courtesy of Etherstack

The portable repeater can support up to 50 customer-programmed operation profiles that transmit and receive on single frequency pairs and has a channel bandwidth (spacing) of 12.5 kHz. GoBox Transportable Repeater's duplexer minimum frequency separation is 4.5 MHz for VHF and 5 MHz for UHF.

The GoBox Transportable Repeater has exterior dimensions of 8.5"L x 10.2"D x 7.8"H and weighs 19.8 lb. This portable repeater is outfitted with protective elements, including a single carry handle, lockable top hinged lid which protects access to network ports, power button, profile selection knob, field swappable batteries and duplexer as well as a separate dc, ac, RJ-45 and N-type antenna connectors. The GoBox is capable of functioning with the lid closed. This product also offers a mounting bracket for vehicles to secure the unit for stowing during normal vehicle operations. The GoBox Transportable Repeater has an operating temperature range of -4 °F to 140 ˚F.

The GoBox Transportable Repeater housing and connector has an IP67 rating and is compliant with the applicable TIA-102 suite of standards[13] [36].

Maintenance is recommended annually and can be conducted by the manufacturer or an approved service provider identified by Etherstack. Maintenance costs vary and maintenance agreements are available for purchase. Additionally, software and firmware updates are provided as needed and are installed either remotely or locally via one of the GoBox's RJ-45 connections.

The GoBox Transportable Repeater has an MSRP of $25,000 that includes initial training and access to training manuals. Warranties and further trainings are available for an additional cost. Customer support is available during standard business hours, while additional support is available via service agreement.

[13] A public safety user can request a copy of any TIA-102 Standard free of charge. A TIA web page, P25 Downloads for Government Entities, describes how to request the TIA-102 Standard that might be of interest. There are many published TIA-102 standards. The internal citation above is to a useful introductory document, "TSB-102-D Project 25 TIA-102 Documentation Suite Overview." TSB-102-D provides a detailed overview of the P25/TIA-102 Standards with feature descriptions as well as the titles and a short summary of all the TIA-102 Standard documents. www.apcointl.org/spectrum-management/spectrum-management-resources/interoperability/p25/p25-committees/

3.11 K.R. NIDA, KR-NIDA-PTR-220

The KR-NIDA-PTR-220 links to 700, 800, and 900 MHz frequencies with an output power of 10-50 watts. Specific frequencies are dependent on the radio embedded in the repeater housing. The KR-NIDA-PTR-220 is powered by a 30-A external power supply. It has an internal 26-A battery for backup and can be daisy chained to multiple external batteries, shore power, generator, or solar panels for long term operation. The repeater supports both analog and digital radios, is compatible with BK Radio and Kenwood models, and also accepts most other dash-mount radios. It supports P25 and uses one key of any encryption type supported by the installed radios. The repeater has a receiver sensitivity of -120 dBm.

Figure 3-11 KR-NIDA-PTR-220
Courtesy of K.R. NIDA Communications

To operate the system, first the antennas need to be deployed. The user then powers up the unit and the radios in the appropriate band, selects the channel/frequency, presses the appropriate radio enable button and the system enable button to make the connection. The PTR-220 controller includes a remote dual-tone multi-frequency (DTMF) keypad to enable and disable each radio, to activate an individual radio, or to activate the entire system.

Depending on the radio used, the portable repeater can support 1-5,000 channels and has a channel bandwidth of 25 kHz, 12.5 kHz analog or 6.25 kHz P25 Phase 1 or 2, DMR or NXDN. The KR-NIDA-PTR-220 has a duplex frequency separation of 3-5 MHz with internal duplexer and 600 kHz with external duplexer. It can also accommodate a trunked format.

The KR-NIDA-PTR-220 has exterior dimensions of 19.7”L x 12”D x 19”H and weighs 60 lb. This portable repeater is outfitted with protective elements, including a Pelican 1440 water resistant case with wheels and handle. It also disassembles to allow for stowing. It has accessory, battery, and power supply boxes. While this repeater is over the weight limit defined in section 1.0, the enclosure is equipped with wheels for easier portability. The KR-NIDA-PTR-220 has an operating temperature range of -22 ˚F to 140 ˚F.

The PTR-220 meets the same standards as the mobile radios installed with the case closed.

Maintenance and calibration are recommended annually. Alignment and maintenance can be completed in less than one to two hours. It is conducted by the manufacturer or an approved service provider and typically costs less than $500. Additionally, software and firmware updates are provided by the radio manufacturer. The purchasing agency can install PC firmware, the cost of which depends on the radio manufacturer. Many radios do not require firmware updates. Updates are installed by PC computer and manufacturer’s software.

The MSRP ranges from $6,000-$30,000 depending on the radios and accessories selected, but at the base price of $4,500, agencies can provide their own radios and KR-NIDA will install and integrate them. A remote training is included with purchase of the repeater. However, in person training can be negotiated, as can be warranties. Customer support is available seven days a week, 24 hours a day.

3.12 KUTTA RADIOS, KUTTA LINK KLR200

The Kutta Radios Kutta Link KLR200 operates on UHF (450-520 MHz) with an output power of 45W or 5W. The repeater also operates on a medium frequency (MF) mode at 450 kHz and 5W. MF mode is further described below. The Kutta Radios Kutta Link KLR200 is powered by an internal battery which has an operating time of 11.5 hours at the 10/10/80 duty cycle and seven hours at a 20/20/60 duty cycle. The repeater can also be operated continuously if powered by an external power supply (110 V ac input to 12 V dc at 18 A output). The repeater has a receiver sensitivity of -119 dBm at 5% BER or -115 dBm at 1% BER and a receiver selectivity of -60 dB for digital communications. For analog communications, the repeater has a -119 dBm sensitivity at 12 dB SINAD and a selectivity of -80 dB when a 25 kHz channel bandwidth is used and -70 dB when 12.5 kHz is used.

Figure 3-12 Kutta Link KLR200
Courtesy of Kutta Radios, Inc

The Kutta Link KLR200 supports analog and digital radios, but it is not compatible with all radio models. For UHF, the KLR-200 has been tested with Motorola and Kenwood handheld radios.

All UHF radios that use standard FM analog modulation or P25 digital modulation are supported. For MF, only Kutta radios are supported. For example, a user could use a DRUM®(R) portable radio to link two KLR-200 units with MF mode and use a DRUM(R) portable radio in between KLR-200 units. The Kutta Link KLR-200 supports the P25 radio standard and used AES and DES encryption methods. It should be noted that the repeater only supports P25 radios when operating in UHF mode as the 450 kHz in MF mode is not a P25 frequency.

For the Kutta Radios Kutta Link KLR200, there are three modes of operation:

1) Command Post Radio Mode. Turning the power switch to the “P” position will activate “post radio” mode. The primary UHF radio powers on and will automatically tune to the first channel in the 45 W post radio channel bank. To transmit, the user speaks into the handset while pressing the push-to-talk (PTT) button on the handset. Audio from the received radio transmissions is produced by both the handset earpiece and the primary radio speaker. The volume of the primary radio speaker can be adjusted up or down using the controls on the primary radio faceplate.

2) UHF Repeater Mode. To configure the “UHF repeater” mode, attach a UHF antenna to the secondary radio UHF antenna port. Place the secondary, external antenna at the maximum practical distance from the KLR-200 unit to avoid the possibility of interference with the built-in primary UHF antenna. Turning the power switch to the “R” position will activate the UHF repeater mode.

Both the primary and secondary UHF radios power on. The primary radio will automatically tune to the first channel in the 5“watt "ho” spot" channel bank, and the secondary UHF radio will t to the first channel in the 45“watt”"link" channel bank. In this mode, any signal received by the primary UHF radio will be repeated as a transmission via the secondary UHF radio, and any signal received by the secondary UHF radio will be repeated as a transmission by the primary UHF radio.

3) Medium Frequency Repeater Mode. To configure the "MF repeater" mode, attach a Kutta medium frequency antenna or accessory to the secondary N-type medium frequency antenna port on the KLR-200. Deploy the MF antenna or accessory according to the directions specific to the unit. Turning the power switch to the "M" position will activate MF repeater mode. In this mode, any signal received by the primary UHF radio will be repeated as a transmission via the Kutta medium frequency interface, and any signal received by the MF interface will be repeated as a transmission by the primary UHF radio.

The portable repeater can support two channels and has a channel bandwidth of UHF: 12.5 kHz, digital & analog: 25 kHz, and analog MF: 16 kHz. The Kutta Radios Kutta Link KLR200 does not have a duplex frequency separation but it does support trunked radio applications.

The Kutta Radios Kutta Link KLR200 has exterior dimensions of 16.2"L x 12.7"D x 6.6"H and weighs 20 lb. This portable repeater is outfitted with protective elements, including a Pelican Storm iM2200 case, which has a rubberized handle and optional shoulder straps. It includes removable primary UHF and secondary UHF antennas, as well as a removable handset. The Kutta Radios Kutta Link KLR200 has an operating temperature range of 32 ˚F to 140 ˚F.

Maintenance or calibration is recommended every three years and can be conducted by the manufacturer or other approved service providers. Maintenance costs vary. The Kutta Radios Kutta Link KLR200 has an MSRP of $20,000 that includes a 90-day manufacturer's warranty. Customer support is available via remote technical support Monday through Friday from 9:00 a.m. to 5:00 p.m. Mountain time.

3.13 MOTOROLA/FUTURECOM, PDR8000 PORTABLE DIGITAL REPEATER

The PDR8000 Portable Digital Repeater is a repeater co-developed by Futurecom Systems Group and Motorola Solutions. The repeater is available in five models:

- 136-174 MHz TX/RX;
- 380-430 TX/RX;
- 450-470 TX/RX;
- 764-776 TX/RX, 794-806 RX; and
- 806-824 TX, 851-869 TX/RX.

Figure 3-13 PDR8000
Courtesy of Motorola Solutions

Cross-band configurations are available for interoperable communications. RF output power ranges between 16 W and 20 W depending on the model. The PDR8000 can be powered either from a 12 V dc or 120 V ac battery. It operates with all analog or P25 portable radios, supports the P25 standard, and is transparent to all P25 encryption. The repeater has a receiver sensitivity of -115 dBm and a receiver selectivity of 60 dB.

The PDR8000 suitcase can be set up to provide local P25 or analog FM on-scene portable radio coverage. To deploy the repeater, users need only to connect antennas and a power source, power up the repeater, and select a channel.

The PDR8000 can support one channel at a time and has channel bandwidth of both 12.5 kHz and 25 kHz. The PDR8000 uses a bandpass filter duplexer with frequency separation of 5 MHz in VHF and UHF. Passband bandwidth is 500 kHz for both the transmit and receive bands. The PDR8000 does not support trunked radio applications.

The PDR8000 has exterior dimensions of 19.2”L x 15.2”D x 7.3”H and weighs 27.8 lb with lithium batteries. This portable repeater is outfitted with protective elements, including a Pelican case. A side cover plate both protects of the connectors during transport and makes the case inconspicuous. A sling and carry pouch can be ordered to aid in carrying. The PDR8000 has an operating temperature range of -22 °F to 131 °F.

The PDR8000 has an IP65 rating and has been tested to meet MIL-STD-810G requirements. The product is also compliant with the IEC 62368-1 safety standard [35].

The PDR8000 is designed to have minimal calibration or service requirements. Maintenance is available by the manufacturer. Diagnostic testing can be done locally. If testing determines full recalibration is necessary, the repeater must be returned to the manufacturer for service. Software and firmware are typically updated annually using a PC and USB cable connection.

The PDR8000 has an MSRP of $15,986 that includes power supply, VHF duplexer, black suitcase, and unity gain antenna. Final pricing will depend upon the selected configuration and warranty options. An initial on-line training session is available at no additional cost. Customizable training packages are available, the cost of which depends on the number of trainees. Electronic product documentation includes specification sheets and comparison charts in addition to training resources. While co-developed by Motorola and Futurecom, the PDR800 is sold exclusively through Motorola Solutions. Training materials and documentation are available on the Futurecom website. In addition to being commercially available, this product is available for purchase through a GSA schedule.

3.14 RCA COMMUNICATION SYSTEMS, RDS RPX8100 P25 DIGITAL RAPID DEPLOYMENT PORTABLE REPEATER

The RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater operates on any one of the following frequency bands: VHF (136-174 MHz); UHF (335-400, 400-480, or 440-520 MHz); and cross-band (VHF 136-174 MHz to UHF 335-400 MHz or VHF 136-174 MHz to UHF 400-470 MHz). In each case, it has an output power range of one to 25 watts. The RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater is powered by an ac- or dc power supply and thus can run on battery, generators, solar or grid outlets. It supports analog and digital radios, is compatible with all makes and models of radios that support P25 Phase 1, and uses both DES-OFB 128-bit or AES 256-bit encryption methods. The repeater has a receiver sensitivity of approximately -117 dBm at 12 dB SINAD and 5% BER. The receiver selectivity is 73 dB when using a 25 kHz channel bandwidth and 65 dB when using a 12.5 kHz bandwidth.

The portable repeater can transmit on a single channel and with a channel bandwidth of 10, 12.5, 20 or 25 kHz. The RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater has an internal duplexer with a frequency separation of 5 MHz for UHF and 4.5 MHz for VHF. A dual antenna set up without a duplexer can be utilized as well as an external duplexer. The repeater can be used with trunked radios only with a dual antenna configuration.

The RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater has exterior dimensions of 18.5”L x 14.1”D x 6.9”H and weighs 20 lb. This portable repeater is outfitted with a wheeled Pelican case with an extendable handle. The repeater, antenna, antenna mount and cable can fitted into the same case. The repeater is ventilated and can be operated with a closed lid. The RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater has an operating temperature range of -22 ˚F to 140 ˚F. The RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater has been tested to MIL-STD-810G.

Figure 3-14 RDS RPX8100 closed (left), with handset (center), without handset (right)
Courtesy of RCA Communications

Maintenance or calibration should be performed as needed and can be conducted by the manufacturer or by an approved service provider. Maintenance costs vary. Software and firmware updates are provided as needed.

The MSRP of the RDS RPX8100 P25 Digital Rapid Deployment Portable Repeater is proprietary and pricing information can be obtained only through a quote from the vendor. Purchase of the repeater includes a three-year warranty and access to product manuals (printed version provided, with electronic versions available on request). Extended warranties are not available. Training is deemed unnecessary as the repeater is plug and play with no user interaction necessary other than providing a power source. Customer support is available via phone or email Monday through Friday, 9:00 a.m. to 8:30 p.m. Eastern time.

3.15 SIMOCO WIRELESS SOLUTIONS, SRB250 P25 RAPID DEPLOYMENT REPEATER

The Simoco Wireless Solutions SRB250 P25 Rapid Deployment Repeater operates on VHF (136-174 MHz) and UHF (400-480 MHz and 440-520 MHz) frequencies with an output power of 25 watts. The SRB250 P25 Rapid Deployment Repeater is powered by lithium ferrophosphate (LFP) batteries for lightweight endurance and optimum voltage for radio modules. An optional external battery box and optional external power supply are available. It supports analog and APCO digital P25 radios, can link into a government radio network (GRN), and can integrate with other digital operations or systems. The SRB250 P25 Rapid Deployment Repeater supports P25 and has DES OFB and AES 256 encryption. In addition to passing encrypted signals, the repeater can also decrypt received signals or encrypt outgoing signals. The repeater has a receiver sensitivity of approximately -117 dBm at 5% BER. The receiver selectivity is 65 dB.

The SRB250 P25 Rapid Deployment Repeater provides deployable on-demand coverage for vehicle and portable radio users in VHF or UHF to keep public safety and government agencies connected. Non-technical staff can deploy it with limited knowledge of professional mobile radio systems.

The portable repeater can support 1,500 channels and has a channel bandwidth of 12.5 kHz. The SRB250 P25 Rapid Deployment Repeater has a duplex frequency separation of 4.6 MHz in the VHF band and 5.2 to 10 MHz in the UHF band, although custom separations are available. The SRB250 is a P25 conventional local area repeater that can be linked to a P25 tuned system with a Simoco link radio.

Figure 3-15 SRB250 P25 Rapid Deployment Repeater

Courtesy of Simoco Wireless Solutions

The SRB250 P25 Rapid Deployment Repeater has exterior dimensions of 19.8”L x 15.8”D x 6.5”H. It weighs less than 32 lb fitted with dual batteries. This portable repeater is embedded within a Pelican briefcase to provide a ruggedized field enclosure. The case allows for easy stowing and transporting and is dustproof and waterproof with a IP55 ingress protection rating. Colors and labeling can be customized to the user. The repeater has an operating temperature range of -4 ˚F to 140 ˚F.

Simoco recommends checking battery capacity and basic radio performance every six months, depending on the use case and environment. The procedure can be carried out by an approved service provider with a VHF/UHF P25 radio test set. The radio performance check takes less than an hour, while the battery capacity check entails running the SRB250 for 24 hours.

Simoco will release software maintenance or feature updates from time to time as required. The updates are installed using a USB programming cable connected to the service ports under the top cover of the SRB250. A software application running on a PC manages the updates.

The SRB250 P25 Rapid Deployment Repeater has an MSRP of $9,025. This includes a two-year warranty and a user manual. Warranty extensions can be quoted upon request. Customer support may originate from the United Kingdom or Australia, covering 16 hours per day. Standard support is five days per week, while higher levels of support for critical applications can be quoted on request.

3.16 TAIT RADIO, TB7300 TRANSPORTABLE REPEATER

The Tait Radio TB7300 Transportable Repeater is a software-defined radio repeater that transmits on VHF and UHF frequencies. The VHF model (TB7304-B370) transmits on 148 to 174 MHz with a duplexer frequency separation of 4.5 MHz. The UHF model (TB7304-H580) transmits on 400 to 470 MHz with a duplexer frequency separation of 5 MHz. Transmission power is adjustable from two watts to a maximum of 30 watts on the VHF model and 25 watts on the UHF model. The TB7300 has a receiver sensitivity of -120 dBm. For digital communications, the repeater has a receiver selectivity of 82 dB in the VHF band and 79 dB in the UHF band. Selectivity is 85 dB for analog communications. The repeater is compatible with all analog and digital radios, is compliant with the P25 radio standard, and supports trunked radio applications. The repeater is also compatible with the Digital Mobile Radio (DMR) standard [37]. The portable repeater can support up to 1000 channels simultaneously with a channel bandwidth of 12.5 kHz. The TB7300 Transportable Repeater is also capable of supporting Time Division Multiple Access (TDMA) communications with this bandwidth, creating a two-channel 6.25 kHz equivalent bandwidth. The repeater is transparent to encryption and will pass any encrypted radio traffic.

Figure 3-16 TB7300 Transportable Repeater
Courtesy of Tait Radios

The TB7300 Repeater can be powered by an external 100-240 V ac power source, an external 11-15 V dc power source, or a removable internal 12 volt 15 Ah/12Ah SLA battery. Battery life is dependent on the transmission power of the repeater. When transmission power is set to 15 watts, estimated battery life is eight hours. The internal battery can be charged with the ac power source. The repeater can also be powered by a vehicle. Clamps are included with the dc power source for usage with a vehicle battery. A separate cigarette lighter cable to charge the internal battery is available for purchase.

The TB7300 Repeater uses a software-defined radio interface for configuration of parameters. Two presets can be saved for quick reconfiguration of the repeater. Once parameters are configured, the repeater is deployed simply by connecting a power source. The repeater can be deployed with other Tait repeaters to create a mixed network composed of fixed base stations as well as transportable repeaters. A web-based interface can be used for monitoring radio traffic through a built-in spectrum analyzer. The web-based interface can also provide critical status alerts to users.

The TB7300 repeater is contained within a Pelican 1550 Protector Case. The case includes handles for easier transport and storage spaces for accessories. The outer dimensions of the product are 18”L x 21”D x 9”H and the entire assembly weighs 50 lb with the internal battery – 42 lb without the battery. The operating temperatures of the repeater range from -22 ˚F to 140 ˚F.

Annual preventative maintenance checks are recommended by the vendor to ensure all components are functioning efficiently. This maintenance can be conducted in-house or by the manufacturer. Software and firmware are updated approximately quarterly and can be downloaded through the Tait Radio website. Remote technical support is available Monday through Friday from 8:00 a.m. to 5:00 p.m. Central time. However, 24-hour options are available upon purchase of the repeater. A basic online training is recommended for repeater operation. This training, along with other user manuals, is available on the Tait Radio website.

The Tait TB7300 Transportable Repeater has an MSRP of $14,928 that includes a basic warranty, regular maintenance costs, and a waterproof ac power wall socket (which must be wired by a registered electrician). An extended hardware warranty and additional support is available for $785. A set of two spare batteries is also available for purchase.

3.17 THALES, TRC6730 20-WATT TACTICAL REPEATER

The Thales TRC6730 20-Watt Tactical Repeater operates on VHF and UHF frequencies (30-512 MHz) with an output power of 20 watts. The TRC6730 20-Watt is powered by AC or DC sources and has the option for solar, supports analog and digital radios, is compatible with ANPRC 148 V1- radios, supports P25 and uses AES, DES and Type 1 encryption methods (if the radio being used supports these types of encryption methods). Repeater mode will retransmit cryptographic signals but will not decrypt signals. The repeater has a receiver sensitivity of -115 dBm.

Figure 3-17 TRC6730 20-Watt
Courtesy of Thales

The TRC6730 20-Watt Tactical Repeater is a suitcase configuration that houses two vehicle adapters that function together as a repeater. The portable repeater provides 20 watts of transmit power in dual antenna configuration and is capable of supporting voice and data transmission.

The portable repeater can support one operational or half duplex channel at a time. However, the radios can be programmed with 256 channels and have a channel bandwidth of 25 kHz. The Thales TRC6730 20-Watt has a duplex frequency separation of 10% between the lowest and highest frequency and does not support trunked radio applications.

The TRC6730-20 Watt has exterior dimensions of 24.6”L x 19.7”D x 11.7”H and weighs 82 lb. This portable repeater is outfitted for stowing and with protection against the elements, including being housed in a Pelican case. While this repeater is over the weight limit defined in section 1.0, the enclosure is equipped with wheels for easier portability. The TRC6730 20-Watt has an operating temperature range of -4 ˚F to 131 ˚F with back-up batteries installed and -23 ˚F to 140 ˚F without back-up batteries installed. The TRC6730 20-Watt meets or exceeds the MIL-STD-810G requirements.

Calibration is not needed. Any required repairs should be made by the manufacturer; maintenance costs vary. Software and firmware updates are provided as needed and are installed via serial port.

The Thales TRC6730 20-Watt has an MSRP of $46,000 that includes a one-year warranty and access to product manuals via a CD. An extended warranty is available for an additional cost. Customer support is available via phone and e-mail 24 hours a day, seven days a week.

3.18 THALES, TRC6730B 50-WATT TACTICAL REPEATER

The Thales TRC6730B 50-Watt Tactical Repeater operates on VHF and UHF frequencies with an output power of 50 watts (30–87.975 MHz) or 20 watts (88–512 MHz). The Thales TRC6730B 50-Watt is powered by ac or dc sources with an option for solar. The repeater supports analog and digital radios, is compatible with ANPRC 148 V1- radios, supports P25, and uses AES, DES and Type 1 encryption methods (so long as the radio being used supports these types of encryption methods). Repeater mode will retransmit cryptographic signals but will not decrypt signals. The repeater has a receiver sensitivity of -115 dBm.

Figure 3-18 TRC6730 50-Watt
Courtesy of Thales

The TRC6730B 50-Watt Tactical Repeater is a suitcase configuration that houses two vehicle adapters that function together as a repeater. The portable repeater provides 50 watts of transmit power in dual antenna configuration and is capable of supporting voice and data transmission.

The portable repeater can support one operational or half duplex channel at a time, however the radios can be programmed with 256 channels and have a channel bandwidth of 25 kHz. The TRC6730B 50-Watt has a duplex frequency separation of 10% between the lowest and highest frequency and does not support trunked radio applications.

The Thales TRC6730B 50-Watt has exterior dimensions of 24.9”L x 23.7”D x 13.1”H and weighs 107 lb. This portable repeater is stowable and outfitted for protective elements, including being housed in a Pelican case. While this repeater is over the weight limit that defined the scope of this market survey (section 1.0), the enclosure is equipped with wheels to ease portability. The repeater has an operating temperature range of -4 ˚F to 131 ˚F with back-up batteries installed and -23 ˚F to 140 ˚F without back-up batteries installed. The TRC6730B 50-Watt has been tested to MIL-STD-810G.

Calibration is not needed. Any required repairs should be made by the manufacturer; maintenance costs vary. Software and firmware updates are provided as needed and are installed via serial port.

The Thales TRC6730B 50-Watt has an MSRP of $51,000 that includes a one-year warranty and access to product manuals via a CD. An extended warranty is available for an additional cost. Customer support is available via phone and e-mail 24 hours a day, seven days a week.

3.19 VAN CLEVE, ECHO 8

The Van Cleve & Associates, Inc. ECHO 8 operates on 150–174 MHz frequencies with an output power of two watts. The repeater is powered by an internal battery or external power source via a 12-14 V dc source, supports both analog and digital radios, is compatible with all radio models, supports P25 and uses the P25 Digital AES-256-bit encryption method. (Note: this is NOT Federal P25 AES-256-bit encryption). The repeater has a receiver sensitivity of -121 dBm.

Figure 3-19 ECHO 8
Courtesy of Van Cleve

To operate the ECHO 8, connect the antenna and power source (if applicable), then turn on the product. Set the operational frequencies and operational mode, then deploy for use.

The portable repeater can support 16 channels and has a channel bandwidth of 12.5 kHz. The ECHO 8 has a duplex frequency separation range of 4.5–10 MHz and does not support trunked radio applications.

The ECHO 8 has exterior dimensions of 10.75”L x 9.75”D x 5”H and weighs 12 lb. This portable repeater is outfitted with protection against the elements, including being built into a Pelican carrying case,. It also features a removable antenna and removable external power cable to allow for stowing. The repeater has an operating temperature range of -22 ˚F to 131 ˚F.

Maintenance and calibration are recommended quarterly and can be conducted in-house, with the exception of battery replacement or adjusting the frequencies outside of the set range—adjustments which must be done by the manufacturer. Maintenance costs vary. No software nor firmware updates are needed for this equipment.

The ECHO 8 has an MSRP of $7,000 which includes a one-year warranty covering parts and labor. Product manuals are provided with the equipment at the time of delivery; they also can be delivered via e-mail upon request. Customer support is available via e-mail or telephone seven days a week from 8:00 a.m. to 8:00 p.m. Eastern time.

3.20 WIRELESS INNOVATION, PORTABLE RADIO REPEATER RAPID DEPLOYMENT KIT

With an output power from one to 25 watts, the Wireless Innovation Portable Repeater Rapid Deployment Kit operates on VHF and UHF frequencies in the following bands 66-88 MHz, 136-174 MHz, 350-400 MHz, 400-470 MHz, 450-527 MHz, and 806-941 MHz. The Portable Repeater Rapid Deployment Kit is powered by an internal lithium ferrophosphate battery that is rechargeable. Alternative power sources include external battery, solar, wind or ac inputs. It supports both analog and digital radios, is compatible with all radio types, supports P25 and uses industry and public safety standards as well as proprietary encryption methods. The repeater has a receiver sensitivity of -116 dBm at 20 dBp[14] SINAD, -118 dBm at 5% BER without antenna diversity, or -121 dBm at 5% BER with antenna diversity. The repeater is built around the Kenwood Kairos rack-mounted repeater. The repeater can also be equipped with a SATCOM interface (available option upon request) and has an optional radio headset that allows the repeater to also serve as a command post radio.

Figure 3-20 Portable Radio Repeater Deployment Kit
without SATCOM interface (left) and with SATCOM interface (right)
Courtesy of Wireless Innovation

The portable repeater can support two channels and has a channel bandwidth of 12.5 or 25 kHz depending on the mode used. Depending on customer requirements, the Portable Repeater Rapid Deployment Kit can provide multiple duplexers with auto switching between them and/or support trunked radio applications.

The Portable Repeater Rapid Deployment Kit has exterior dimensions of 25”L x 20”D x 12”H and weighs up to 65 lb, depending on the configuration. This repeater is outfitted with protective elements, including stackable and hardened ruggedized plastic cases that can be outfitted with wheels or carried with a padded backpack harness. The system can also be broken down on a modular basis for improved portability as per customer request. The antenna is designed to be rolled up for easy portability and storage. While this repeater is over the weight limit cited in section 1.0, the enclosure’s optional wheels, backpack harness and modular design allow for its portability. The Portable Repeater Rapid Deployment Kit has an operating temperature range of -22 ˚F to 140 ˚F. The Portable Repeater Rapid Deployment Kit is compliant with the DMR standard [37] and has an IP65 rating.

No specific regular maintenance is recommended; when needed, however, service can be conducted by the manufacturer or by an approved service provider.

[14] The unit dBp refers to decibels relative to peak power, rather than the average power, of the signal.

No recalibration is needed unless the frequencies are adjusted outside of the set range, something which should be addressed by the manufacturer. Maintenance costs vary. Software and firmware updates are provided as needed, typically annually, and are installed remotely.

The Portable Repeater Rapid Deployment Kit has a starting MSRP of $16,000 that includes a warranty (based on the electronic components included), training, and access to downloadable product manuals. Extended warranties up to five years and premium warranties with various service level agreements are available at additional cost. Customer support is available by phone at any time.

4.0 VENDOR CONTACT INFORMATION

Additional information on the portable radio repeaters included in this report can be obtained from the vendors listed in Table 4-1.

Table 4-1 Vendor Contact Information

Vendor	Address	Phone Number	E-mail Address
ABP	8677 Grovemont Circle Gaithersburg, MD 20877	301-977-5570	info@abp.com
BK Technologies	7100 Technology Drive Melbourne, FL 32904	321-953-7809	sales@bktechnologies.com
Catalyst Communications	2107 Graves Mill Road Mail Stop D Forest, VA 24551	434-582-6146	info@catcomtec.com
Cell Antenna Wireless	12453 NW 44th Street Coral Springs, FL 33065	954-340-7053	sales@cellantenna.com
Codan Communications	19955 Highland Visa Drive Suite 145 Ashburn, VA 20147	250-382-8268	LMRsales@codancomms.com
Etherstack	1115 Broadway, 12th Floor New York, NY 10010	917-661-4110	info.na@etherstack.com
Futurecom Systems Group*	3277 Langstaff Road Concord, ON L4K 5P8 Canada	905-660-5548	sales@futurecom.com
KR-NIDA	3827 Foothill Boulevard La Crescenta, CA 91214	818-957-1248	Inquiries through vendor website
Kutta Radios	2075 W Pinnacle Peak Road, Suite 102 Phoenix, AZ 85027	602-896-1976	CustomerSupport@KuttaTech.com
Motorola Solutions	809 Pinnacle Drive Linthicum Heights, MD 21090	888-325-9336	Inquiries through vendor website
RCA Communications	555 West Victoria Street Compton CA 90220	800-895-5122	sales@rcacommunicationssystems.com
SIMOCO Wireless Solutions	Field House Uttoxeter Old Road Derby DE1 1NH United Kingdom	+44 (0) 1332 375 500	info@simocowirelesssolutions.com
Tait Radios	15354 Park Row Drive Houston, TX 77084	281-928-3300	Inquiries through vendor website
Thales	22605 Gateway Center Drive Clarksburg, MD 20871	800-258-4420	solutions@thalesdsi.com
Van Cleve & Associates, Inc.	7910 Andrus Road Suite 4 Alexandria, VA 22306	703-619-4007	vcainc@vcasecurity.com
Wireless Innovation	1949 5th Street, Suite 104 Davis, CA 95616	530-203-8480	sales@wirelessinnovation.com

* While Futurecom can be contacted for information on the Motorola/Futurecom PDR8000, the repeater is sold exclusively by Motorola Solutions.

5.0 CONCLUSIONS

Radio communications can be degraded in indoor and underground emergency response operations due to poor coverage and line of sight obstructions. First responders may deploy a radio repeater to overcome this challenge and support communications in indoor and subterranean environments.

This market survey provides information on 20 commercially available portable radio repeaters deployable for indoor and underground operations. All products in this MSR are human-portable, contained within a protective enclosure, and compliant with the P25 radio standard. The products in this report operate in the VHF, UHF and 700/800 MHz frequency bands. Maximum RF transmission power ranges from 0.5 to 110 watts. The products described range in price from $3,700 to $51,000.

Some of the repeaters in this MSR include features such as a command post radio mode, a software-defined radio interface for re-configuration and monitoring, modular construction for enhanced portability, and/or network interfaces for compatibility with cellular LTE and SATCOM networks.

Emergency responder agencies that consider purchasing portable radio repeaters for indoor and subterranean environments should carefully research each product's specifications (such as frequency and transmission power), capabilities, and limitations. Agencies should also consider how the product can be deployed to maximize coverage range and signal quality in its intended operating environment. These considerations may include the physical layout and characteristics of the environment and the positioning of the repeater and antennas.

Appendix A. MIL-STD-810 Test Methods

Table A-1 lists test methods described in MIL-STD-810G (published in 2008) [28].

Table A-1 MIL-STD-810G (2008) Test Methods

Method Number	Title	Purpose
500	Low Pressure (Altitude)	Use low pressure (altitude) tests to determine if materiel can withstand and/or operate in a low-pressure environment and/or withstand rapid pressure changes.
501	High Temperature	Use high temperature tests to obtain data to help evaluate effects of high-temperature conditions on material safety, integrity, and performance.
502	Low Temperature	Use low temperature tests to obtain data to help evaluate effects of low temperature conditions on materiel safety, integrity, and performance during storage, operation, and manipulation.
503	Temperature Shock	Use the temperature shock test to determine if materiel can withstand sudden changes in the temperature of the surrounding atmosphere without experiencing physical damage or deterioration in performance.
504	Contamination by Fluids	Use contamination by fluids test to determine if materiel (or material samples) is affected by temporary exposure to contaminating fluids (liquids) such as may be encountered and applied during its life cycle, either occasionally, intermittently, or over extended periods.
505	Solar Radiation (Sunshine)	This method has two purposes, (1) to determine the heating effects of direct solar radiation on materiel, and (2) to help identify the actinic (photodegradation) effects of direct solar radiation.
506	Rain	Determine the following with respect to rain, water spray, or dripping water: (1) The effectiveness of protective covers, cases, and seals in preventing the penetration of water into the materiel; (2) The capability of the materiel to satisfy its performance requirements during and after exposure to water; (3) Any physical deterioration of the materiel caused by the rain; (4) The effectiveness of any water removal system; and (5) The effectiveness of protection offered to a packaged materiel.
507	Humidity	Determine the resistance of materiel to the effects of a warm, humid atmosphere.
508	Fungus	Assess the extent to which materiel will support fungal growth and how any fungal growth may affect performance or use of the materiel.

Method Number	Title	Purpose
509	Salt Fog	Determine the effectiveness of protective coatings and finishes on materials. It may also be applied to determine the effects of salt deposits on the physical and electrical aspects of materiel.
510	Sand and Dust	Dust (< 150µm) procedure – evaluate the ability of materiel to resist the effects of dust that may obstruct openings, penetrate into cracks, crevices, bearings, and joints, and to evaluate the effectiveness of filters. Sand (150 to 850µm particle size) procedure – performed to help evaluate the ability of materiel to be stored and operated in blowing sand conditions without degrading performance, effectiveness, reliability, and maintainability due to abrasion (erosion) or clogging effects of large, sharp-edged particles.
511	Explosives Atmosphere	Demonstrate the ability of materiel to operate in fuel-air explosive atmospheres without causing ignition or demonstrate that an explosive or burning reaction occurring within encased materiel will be contained and will not propagate outside the test item.
512	Immersion	Determine if materiel can withstand immersion or partial immersion in water (e.g., fording), and operate as required during or following immersion.
513	Acceleration	Assure that materiel can structurally withstand the steady state inertia loads that are induced by platform acceleration, deceleration, and maneuver in the service environment, and function without degradation during and following exposure to these forces. Acceleration tests are also used to assure that materiel does not become hazardous after exposure to crash inertia loads.
514	Vibration	Performed to (1) develop materiel to function in and withstand the vibration exposures of a life cycle including synergistic effects of other environmental factors, materiel duty cycle, and maintenance. This method is limited to consideration of one mechanical degree-of-freedom at a time. Refer to Method 527 for further guidance on multiple exciter testing. Combine the guidance of this method with the guidance of Part One and other methods herein to account for environmental synergism. (2) Verify that materiel will function in and withstand the vibration exposures of a life cycle.
515	Acoustic Noise	Determine the adequacy of materiel to resist the specified acoustic environment without unacceptable degradation of its functional performance and/or structural integrity.

Method Number	Title	Purpose
516	Shock	Performed to provide a degree of confidence that materiel can physically and functionally withstand the relatively infrequent, non-repetitive shocks encountered in handling, transportation, and service environments. This may include an assessment of the overall materiel system integrity for safety purposes in any one or all of the handling, transportation, and service environments; determine the materiel's fragility level, in order that packaging may be designed to protect the materiel's physical and functional integrity; and test the strength of devices that attach materiel to platforms that can crash.
517	Pyroshock	Performed to provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by the detonation of a pyrotechnic device on a structural configuration to which the materiel is mounted; and experimentally estimate the materiel's fragility level in relation to pyroshock in order that shock mitigation procedures may be employed to protect the materiel's structural and functional integrity.
518	Acidic Atmosphere	Determine the resistance of materials and protective coatings to corrosive atmospheres, and when necessary, to determine its effect on operational capabilities.
519	Gunfire Shock	Performed to provide a degree of confidence that materiel can structurally and functionally withstand the relatively infrequent, short duration, transient, high rate repetitive shock-input encounter in operational environments during the firing of guns.
520	Temperature, Humidity, Vibration, and Altitude	Determine the combined effects of temperature, humidity, vibration, and altitude on airborne electronic and electro-mechanical materiel with regard to safety, integrity, and performance during ground and flight operations. Some portions of this test may apply to ground vehicles, as well. In such cases, references to altitude considerations do not apply.
521	Icing/Freezing Rain	Evaluate the effect of icing on the operational capability of materiel. This method also provides tests for evaluating the effectiveness of de-icing equipment and techniques, including prescribed means to be used in the field.
522	Ballistic Shock	This method includes a set of ballistic shock tests generally involving momentum exchange between two or more bodies, or momentum exchange between a liquid or gas and a solid, performed to provide a degree of confidence that materiel can structurally and functionally withstand the infrequent shock effects caused by high levels of momentum exchange on a structural configuration to which the materiel is mounted; and experimentally estimate the materiel's fragility level relative to ballistic shock in order that shock-mitigation procedures may be employed to protect the materiel's structural and functional integrity.

Method Number	Title	Purpose
523	Vibro-Acoustic/Temperature	Performed to determine the synergistic effects of vibration, acoustic noise, and temperature on externally carried aircraft stores during captive carry flight. Such determination may be useful for, but not restricted to, the following purposes: (1) To reveal and correct design weaknesses (Test, Analyze, and Fix (TAAF) test); (2) To determine whether a design meets a specified reliability requirement (Reliability Demonstration test); (3) To reveal workmanship or component defects before a production unit leaves the place of assembly (Screening test); (4) To estimate the Mean Time Between Failure (MTBF) of a lot of units based upon the test item's time to failure of a small sample of the units (Lot Acceptance test); and (5) To determine the relative reliability among units based upon the test item's time to failure of a small sample of the units (Source Comparison test).
524	Freeze-Thaw	Determine the ability of materiel to withstand the effects of moisture phase changes between liquid and solid, in or on materiel, as the ambient temperature cycles through the freeze point; and the effects of moisture induced by transfer from a cold-to-warm or warm-to-cold environment.
525	Time Waveform Replication	Performed to provide a degree of confidence that the materiel can structurally and functionally withstand the measured or analytically specified test time trace(s) to which the materiel is likely to be exposed in the operational field environment; and experimentally estimate the materiel's fragility level in relation to form, level, duration, or repeated application of the test time trace(s).
526	Rail Impact	Replicate the railroad car impact conditions that occur during the life of transport of systems, subsystems, and units, hereafter called materiel, and the tiedown arrangements during the specified logistic conditions.
527	Multi-Exciter Testing	Performed to provide a degree of confidence that the materiel can structurally and functionally withstand a specified environment, e.g., stationary, non-stationary, or of a shock nature, that must be replicated on the test item in the laboratory with more than one motion degree-of-freedom consideration.
528	Mechanical Vibrations of Shipboard Materials	Specifies procedures and establishes requirements for environmental and internally excited vibration testing of naval shipboard equipment installed on ships

Appendix B. IP and NEMA Enclosure Ratings

This appendix contains additional information on safety and durability standards that are referenced in section 2.3.4. Table B-1 and Table B-2 list solid and liquid IP ratings respectively (as defined in IEC60529) [30]. Table B-3 lists NEMA enclosure ratings (as defined in NEMA 250-2018) [31] and their IP equivalents [32].

Table B-1 Solid IP Ratings

Solid IP Rating	Object Size Protected Against	Effective Against
0	Not protected	No protection against contact and ingress of objects
1	>50 mm	Any large surface of the body, such as the back of the hand, but no protection against deliberate contact with a body part.
2	>12.5 mm	Fingers or similar objects.
3	>2.5 mm	Tools, thick wires, etc.
4	>1 mm	Most wires, screws, etc.
5	Dust protected	Ingress of dust is not entirely prevented, but it must not enter in sufficient quantity to interfere with the satisfactory operation of the equipment; complete protection against contact.
6	Dust tight	No ingress of dust; complete protection against contact.

Table B-2 Liquid IP Ratings

Liquid IP Rating	Object Size Protected Against	Effective Against
0	Not protected	--
1	Dripping water	Dripping water (vertically falling drops) shall have no harmful effect.
2	Dripping water when tilted up to 15°	Vertically dripping water shall have no harmful effect when the enclosure is tilted at an angle up to 15° from its normal position.
3	Spraying water	Water falling as a spray at any angle up to 60° from the vertical shall have no harmful effect.
4	Splashing water	Water splashing against the enclosure from any direction shall have no harmful effect.
5	Water jets	Water projected by a nozzle (6.3mm) against enclosure from any direction shall have no harmful effects.
6	Powerful water jets	Water projected in powerful jets (12.5mm nozzle) against the enclosure from any direction shall have no harmful effects.
7	Immersion up to 1 m	Ingress of water in harmful quantity shall not be possible when the enclosure is immersed in water under defined conditions of pressure and time (up to 1 m of submersion).
8	Immersion beyond 1 m	The equipment is suitable for continuous immersion in water under conditions which shall be specified by the manufacturer. Normally, this will mean that the equipment is hermetically sealed. However, with certain types of equipment, it can mean that water can enter but only in such a manner that it produces no harmful effects.
9/9K	Powerful high-temperature water jets	Protected against close-range high pressure, high-temperature spray downs. Equipment under test shall experience no harmful effects from the high-pressure and high-temperature water spray. IPX9 is used for fixed installation equipment in a facility, while IPX9K is used for equipment installed upon vehicles.

Table B-3 NEMA Enclosure Ratings (2018)

NEMA Enclosure Rating	NEMA Definition	Equivalent IP Rating
1	General purpose. Protects against dust, light, and indirect splashing but is not dust-tight; primarily prevents contact with live parts; used indoors and under normal atmospheric conditions.	IP10
2	Drip-tight. Similar to Type 1 but with addition of drip shields; used where condensation may be severe (as in cooling rooms and laundries).	IP11
3 and 3S	Weather-resistant. Protects against weather hazards such as rain and sleet; used outdoors on ship docks, in construction work, and in tunnels and subways.	IP54
3R	Intended for outdoor use. Provides a degree of protection against falling rain and ice formation. Meets rod entry, rain, external icing, and rust-resistance design tests.	IP14
4 and 4X	Watertight (weatherproof). Must exclude at least 65 GPM of water from 1-in. nozzle delivered from a distance not less than 10 ft for 5 min. Used outdoors on ship docks, in dairies, and in breweries.	IP56
5	Dust-tight. Provided with gaskets or equivalent to exclude dust; used in steel mills and cement plants.	IP52
6 and 6P	Submersible. Design depends on specified conditions of pressure and time; submersible in water; used in quarries, mines, and manholes.	IP67
7	Hazardous. For indoor use in Class I, Groups A, B, C, and D environments as defined in the NEC.	–
8	Hazardous. For indoor and outdoor use in locations classified as Class I, Groups A, B, C, and D as defined in the NEC.	–
9	Hazardous. For indoor and outdoor use in locations classified as Class II, Groups E, F, or G as defined in the NEC.	–
10	MSHA. Meets the requirements of the Mine Safety and Health Administration, 30 CFR Part 18 (1978).	–
11	General-purpose. Protects against the corrosive effects of liquids and gases. Meets drip and corrosion-resistance tests.	–
12 and 12K	General-purpose. Intended for indoor use, provides some protection against dust, falling dirt, and dripping noncorrosive liquids. Meets drip, dust, and rust resistance tests.	IP52
13	General-purpose. Primarily used to provide protection against dust, spraying of water, oil, and noncorrosive coolants. Meets oil exclusion and rust resistance design tests.	IP54

6.0 REFERENCES

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