Mobexcom P25 DVRS Technical Evaluation

The Office for Interoperability and Compatibility
Department of Homeland Security

Overview and Test Results

Homeland Security

TE-08-0005
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Command, Control and Interoperability: Communication, Interoperability and Compatibility

Homeland Security
Science and Technology

Defining the Problem

Emergency responders—police officers, fire personnel, emergency medical services—need to share vital voice and data information across disciplines and jurisdictions to successfully respond to day-to-day incidents and large-scale emergencies. Unfortunately, for decades, inadequate and unreliable communications have compromised their ability to perform mission-critical duties. Responders often have difficulty communicating when adjacent agencies are assigned to different radio bands, use incompatible proprietary systems and infrastructure, and lack adequate standard operating procedures and effective multi-jurisdictional, multi-disciplinary governance structures.

OIC Background

The Department of Homeland Security (DHS) established the Office for Interoperability and Compatibility (OIC) in 2004 to strengthen and integrate interoperability and compatibility efforts to improve local, tribal, state, and Federal emergency response and preparedness. Managed by the Science and Technology Directorate, and housed within the Communication, Interoperability and Compatibility thrust area, OIC helps coordinate interoperability efforts across DHS. OIC programs and initiatives address critical interoperability and compatibility issues. Priority areas include communications, equipment, and training.

OIC Programs

OIC programs, which are the majority of Communication, Interoperability and Compatibility programs, address both voice and data interoperability. OIC is creating the capacity for increased levels of interoperability by developing tools, best practices, technologies, and methodologies that emergency response agencies can immediately put into effect. OIC is also improving incident response and recovery by developing tools, technologies, and messaging standards that help emergency responders manage incidents and exchange information in real time.

Practitioner-Driven Approach

OIC is committed to working in partnership with local, tribal, state, and Federal officials to serve critical emergency response needs. OIC's programs are unique in that they advocate a "bottom-up" approach. OIC's practitioner-driven governance structure gains from the valuable input of the emergency response community and from local, tribal, state, and Federal policy makers and leaders.

Long-Term Goals

- Strengthen and integrate homeland security activities related to research and development, testing and evaluation, standards, technical assistance, training, and grant funding.
- Provide a single resource for information about and assistance with voice and data interoperability and compatibility issues.
- Reduce unnecessary duplication in emergency response programs and unneeded spending on interoperability issues.
- Identify and promote interoperability and compatibility best practices in the emergency response arena.

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Department of Homeland Security (DHS)

Science and Technology Directorate (S&T)

Office for Interoperability and Compatibility (OIC)

TECHNOLOGY EVALUATION PROJECT

Technical Evaluation of the Mobexcom P25 Digital Vehicular Repeater System

Manufactured by Futurecom Systems Group, Inc.

Overview and Test Results

Document No. TE-08-0005

December 2007

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Publication Notice

Abstract

This report summarizes the results obtained from the evaluation of the Mobexcom P25 Digital Vehicular Repeater System (DVRS). The Mobexcom P25 DVRS is designed to enable interoperability between wireless public safety communication systems. It does this by establishing a wireless link between the DVRS and a trunked radio system. For information about the testing procedures used to obtain the results described here, see the test results companion document: *Technical Evaluation of the Mobexcom P25 Digital Vehicular Repeater System – Test Procedures and Feature Configuration* (Document No. TE-08-0006).

Disclaimer

The U.S. Department of Homeland Security's Science and Technology Directorate serves as the primary research and development arm of the Department, using our Nation's scientific and technological resources to provide local, state, and Federal officials with the technology and capabilities to protect the homeland. Managed by the Science and Technology Directorate, the Office for Interoperability and Compatibility (OIC) is assisting in the coordination of interoperability efforts across the Nation.

Certain commercial equipment, materials, and software are sometimes identified to specify technical aspects of the reported procedures and results. In no case does such identification imply recommendations or endorsement by the U.S. Government, its departments, or its agencies; nor does it imply that the equipment, materials, and software identified are the best available for this purpose.

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Executive Summary

OIC conducted a series of tests to evaluate the functionality of the Mobexcom P25 Digital Vehicular Repeater System (DVRS). ("P25" stands for "Project 25.") The DVRS is composed of two parts. One system component is the Mobexcom Digital Vehicular Repeater (DVR). It is manufactured by Futurecom Systems Group, Inc. (http://www.futurecom.com). The second component of the DVRS is the Motorola XTL 5000 with an O5 Control Head. It is manufactured by Motorola, Inc. (http://www.motorola.com). The DVRS is part of a collection of vehicular repeater technology products offered by various manufacturers.

This report summarizes the results obtained from the evaluation of the Mobexcom P25 DVRS. To evaluate the Mobexcom P25 DVRS, testing was divided into two groups, specification and feature tests. The specification-based tests verify whether the Mobexcom DVRS conforms to the specifications published by the manufacturer. The feature-based tests verify whether advertised features function as the manufacturer's documentation describes. The feature tests also help users understand the use of particular features and how to configure them for correct operation. For information about the testing procedures used to obtain the results described here, see the test results companion document: *Technical Evaluation of the Mobexcom P25 Digital Vehicular Repeater System – Test Procedures and Feature Configuration* (Document No. TE-08-0006).

Overall, the DVR performed, as detailed by this document, according to the vendor's published specification. Other observations that this document describes include:

- *RF (radio frequency) emissions*. Informal testing showed very little likelihood that the Mobexcom P25 DVRS will interfere with other electronic devices in its vicinity.
- *User guide discrepancies*. A handful of feature-based tests were assigned a status of "Inconclusive" and "Pass with Exceptions" due to discrepancies or errors in the documentation set, where feature operation was described differently across the documentation set, or a document contradicted itself when describing a feature.
- *Computer required for DVRS configuration*. The DVR comes with configuration software, known as Tweaker. The Motorola mobile Customer Programming Software (CPS) required to program the mobile radio (Motorola XTL 5000) is not included, unless requested when placing the order for the DVRS. Significant configuration (or programming) of the DVRS is necessary before deployment.
- *Manufacturer responsiveness*. The manufacturer was very responsive in answering device operation and feature configuration questions. They even sent an engineer on-site to assist with some specification-based testing.

Document Scope and Intended Audience

This report provides the results for each feature and specification-based test executed against the DVRS. The technical nature of this document should assist anyone who might purchase or operate the Mobexcom P25 DVRS.

1 Introduction

Public safety operations require effective command, control, coordination, communication, and sharing of information with numerous criminal justice and public safety agencies, as well as with public utilities, transportation companies, and others in private industry. Thousands of incidents that require mutual aid and coordinated response occur every day. High-profile incidents, such

as bombings or plane crashes, test the ability of public safety service organizations to mount well-coordinated responses. In an era where technology can bring news, current events, and entertainment to the farthest reaches of the world, many law enforcement officers, firefighters, and emergency medical service (EMS) personnel cannot communicate with each other during major emergencies, as evidenced by September 11, 2001, and Hurricanes Katrina and Rita, or even during routine traffic accident or fire operations.

1.1 Bridging Communications Gaps

There are more than 18,000 state and local law enforcement agencies in the United States. Approximately 95 percent of these agencies employ fewer than 100 sworn officers. Additionally, more than 32,000 fire and EMS agencies exist across the Nation. Due to the fragmented nature of this community, many public safety communications systems are stovepiped, i.e., individual systems do not communicate with one another or help bring about interoperability. Just as the public safety community is fragmented, so is radio spectrum. Public safety radio frequencies are distributed across isolated frequency bands, from very high frequency (VHF) (25 to 50 megahertz (MHz)) to 800 MHz (806 to 869 MHz), and now 4.9 gigahertz (GHz).

The convergence of information and communication technologies requires a coordinated approach to bridge the gaps in interoperability. By focusing on enabling technologies and open standards for interoperability, the Department of Homeland Security's (DHS) Office for Interoperability and Compatibility (OIC) Technology Evaluation Project provides this needed link.

1.2 The OIC Technology Evaluation Project

The OIC Technology Evaluation Project is focused on assessing the applicability of currently available and evolving products and services to the interoperability requirements of users in public safety agencies. To accomplish this, products and services are evaluated to determine if they are both cost-efficient and effective for users. They also are evaluated consistent with the tenets of the long-term standardization approach developed by OIC for nationwide interoperability.

Evaluation comprises classic techniques, including observation, analysis, demonstration, and testing. In many cases, products or services may be comprehensively evaluated within an independent laboratory or other closed environment. For other products or services, however, a more extensive approach may be necessary to determine the ramifications of placing those products or services in an agency conducting actual job functions. To help with the demonstrations and testing of selected products or services of this type, operational test beds (OTBs) may be established. This aim is to assess the operational impacts of technologies that assist interoperability. In addition, focused "pilot projects" are also used to evaluate solutions to specific operational requirements.

While evaluation processes conducted at independent laboratories may take weeks to complete (for example, 4 to 8 weeks), evaluations within the OTB may take months (for example, 6 to 12 months). This is because such evaluations carefully characterize the impact of the new product or service on existing operations. In addition, they project how future operations may change with a permanent application of the technology.

2 Background

A fundamental interoperability challenge today is wireless voice communications among agencies that have different radio systems operating on various radio frequencies. OIC will ultimately address this issue through adoption of interoperability standards, including standardized methods of bridging systems operating in different frequency bands.

While interoperability standards are developed, however, other mechanisms are needed that can address interoperability requirements. One such mechanism is the digital vehicular repeater system (DVRS) that links disparate radio systems. The Mobexcom P25 DVRS allows portable subscriber unit (PSU) radio use in areas where only mobile subscriber unit (MSU) radio coverage is available, and PSU coverage is either intermittent or non-existent. The DVRS can be configured for use in an MSU platform (for example, in a police squad car or an SUV) to become part of an incident commander's command post. The DVRS extends radio communications when PSU users are outside of the vehicle, inside a nearby building, or in any PSU marginal coverage areas. Further, the DVRS allows the disparate radio systems to communicate in a wide geographical radius around the incident.

2.1 Overview of the Mobexcom P25 DVRS

The Mobexcom P25 DVRS is designed to enable interoperability between wireless communication systems. It does this by establishing a wireless link between the DVRS and a trunked radio system. The DVRS comprises two components: the MSU (Motorola XTL 5000), and the repeater unit (the DVR).

The MSU communicates with a trunked P25 system. The repeater unit serves PSUs that are outside the range of the trunked system. These PSUs are referred to as "local-side" PSUs. The repeater unit is interfaced to the MSU via a 25-pin cable. Since the MSU is capable of communicating with the trunked radio system, this link allows the local-side PSUs to communicate with PSUs that are served exclusively by the trunked radio system. These PSUs are referred to as "system-side" PSUs. The wireless link to the trunked system also allows local-side PSUs to communicate with dispatchers.

The DVRS behaves like any other conventional repeater, except it can communicate with a trunked radio system, and it is portable. The DVRS is essentially capable of extending the coverage area of a trunked system to PSUs that are out of range of the trunked radio system. This extension includes extending talk groups (TGs) that are configured in the trunked radio system to the local-side PSUs during a group call.

A local-side PSU can set up a private call with a system-side PSU. In addition, a user can create a network of DVRSs on an ad hoc basis. Of course, each DVRS has to be programmed to enable communication among all DVRSs that comprise the network.

As with any other trunked or conventional repeater, group calls and private calls are allowed. In a group call, one user can simultaneously broadcast, using the Mobexcom P25 DVRS, to several radios. (The radios may be local-side only, or local- and system-side, depending on the mode.) A local-side PSU can also set up a private call with a specific system-side PSU, and vice versa.

No load testing was performed to determine the maximum number of subscriber units the Mobexcom P25 DVRS can support during a group call on the local-side. The number of subscribers that can be supported on the system side is a function of the trunked radio system.

Figure 1 illustrates how the DVRS can be integrated with a trunked system to help solve interoperability issues.

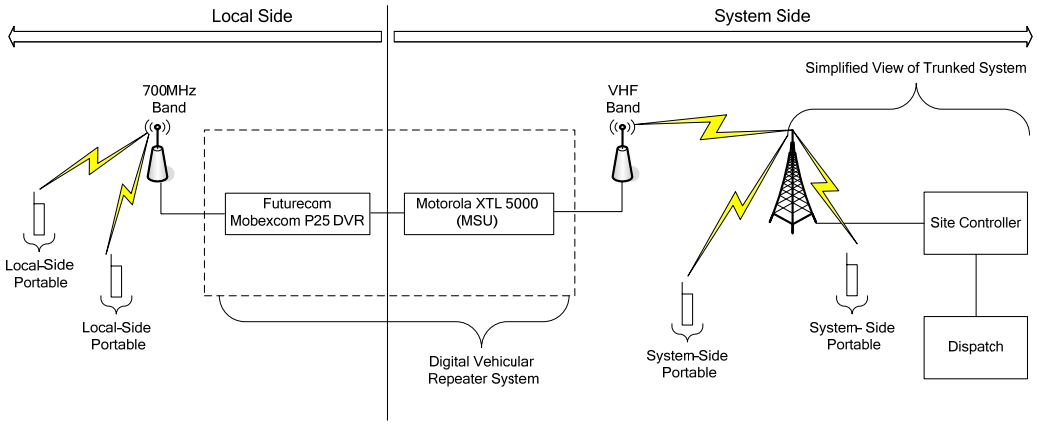

Figure 1: Cross-Band DVRS Configuration Integrated with a Trunked System

2.2 Features and Illustrations

The cross-band version of the Mobexcom P25 DVRS in Figure 1 can support Motorola XTS 5000 P25 PSUs, generic PSUs, and analog PSUs. Depending on the type of PSU, the DVRS can support the features in Table 1.

Table 1: DVRS Features per PSU Type

DVRS Feature	XTS 5000 P25 PSU	Generic P25 PSU	Analog PSU
Registration/De-Registration with a Trunked System	Yes	Yes	No
Group Call	Yes	Yes	Yes
Private Call	Yes	No	No
Emergency Call/Alarm	Yes	Yes	Yes
Encrypted Call	Yes	Yes	No
Portable PTT (Push-To-Talk) ID Pass Through	Yes	Yes	No
Call Alert Paging	Yes	Yes	No
Failsoft Indication Generated by Trunked System	Yes	No	No
Out of Range Indication Generated by Trunked System	Yes	No	No
Site Trunking Indication Generated by Trunked System	Yes	No	No
Talk Permit Tones (Generated by PSU)	Yes	No	No
Talk Permit Tones Generated by the DVR	No	No	Yes
Radio Inhibit Originated by Dispatch or Network Management Software	Yes	Yes	No
Radio Check Originated by Dispatch or Network Management Software	Yes	Yes	No

DVRS Feature	XTS 5000 P25 PSU	Generic P25 PSU	Analog PSU
Remote Control of DVRS via Call Alert	Yes	Yes	No
Remote Control of DVRS via Emergency Call/Alarm	Yes	Yes	Yes (MDC 1200)

The following features, in Table 2, are available depending on the mode in which the P25 digital DVRS is operating. Some features of the DVRS are also affected by the PSU type that is being used.

Table 2: Features Available Per Digital DVRS Mode

Feature	DVR Mode: OFF	DVR Mode: SYSTEM	DVR Mode: LOCAL
DVRS Status Display on the O5 Control Head	VR OFF <DVR CH>	VR SYS <DVR CH>	VR LOC <DVR CH>
PSU Affiliation	No	Yes	Yes
Outbound Group Call	No	Yes	Yes
Outbound Private Call	No	Yes	Yes
Mobile (XTL 5000) Microphone PTT	No	No	No
Inbound Group Call	No	Yes	Yes
Inbound Private Call	No	Yes	Yes
Inbound Call Alert	No	Yes	Yes
Inbound Emergency Alarm	Yes	Yes	Yes
Inbound Emergency Call	Yes	Yes	Yes
Remote Control (Steering) of DVRS Using a PSU	Yes	Yes	Yes
Failsoft Indication Generated by Trunked System	No	Yes	No
Out of Range Indication Generated by Trunked System	No	Yes	No
Site Trunking Indication Generated by Trunked System	No	Yes	No
Master/Slave Voting	No	Yes	Yes
DVRS Status Tones at the Mobile (XTL 5000) Speaker	No	Yes	Yes
DVRS Status Tones Passed to the PSU	No	Yes	Yes
Radio Inhibit Originated by Dispatch or Network Management Software	No	Yes	Yes
Radio Check Originated by Dispatch or Network Management Software	No	Yes	Yes

Figure 2: Mobexcom DVRS—Cross-Band, Side-by-Side, Mounted Version[1]

The left side of Figure 2 shows the DVR portion of the side-by-side version of the Mobexcom P25 DVRS in a metal case with a metal face plate. The right side of Figure 2 shows the MSU portion in a ruggedized metal casing, with the exception of the O5 Control Head. Configuration of the DVR requires a computer attached via a standard USB cable (not included). Configuration of the MSU requires a computer attached via a non-standard USB cable. This non-standard USB to round cable is available only from Motorola, Inc. for about $45.

The DVR comes with configuration software, known as Tweaker. The Motorola mobile CPS programming software required to program the mobile radio (Motorola XTL 5000) is not included, unless requested when placing the order for the DVRS. A computer meeting the following minimum requirements is necessary: Windows 2000 or newer, 400MHz or higher CPU, 128 MB of RAM (256 MB of RAM if running Windows XP), CD-ROM drive, two USB ports, and a serial port. PSUs are not provided with the DVRS.

In addition to the side-by-side configuration, Futurecom offers a transportable and a fixed DVRS package. Figure 3 shows the transportable DVRS and battery package. The transportable DVRS is housed in a durable suitcase, and includes all necessary electronics and filtering. The transportable package can be powered by either AC power or an optional battery backup kit. The battery backup kit is also packaged in a suitcase. The transportable package requires two antennas, one for the XTL 5000 and one for the DVR.

[1] Picture obtained from the *Mobexcom User's Guide*, Part No. 8A083X20, Rev. 0.

Figure 3: Transportable DVRS Package (left) and Associated Battery Pack (right).[2]

Figure 4 shows the fixed DVRS package designed for permanent installations. The fixed DVRS package is housed in a wall-mount indoor enclosure, and includes all necessary electronics and filtering.

Figure 4: Fixed DVRS Package[3]

Setup and operation of the unit for all testing was conducted in accordance with the:

- *Mobexcom P25 DVRS Installation & Programming Guide*, Part No. 8M083X01, Rev. 1
- *Mobexcom P25 Digital Vehicular Repeater User's Guide*, Part No. 8A083X20, Rev. 0
- *Mobexcom P25 Functional Description*, Part No. 8K083X01, Rev. 3

The unit was conformance-tested in accordance with vendor-supplied product specifications detailed in the Mobexcom documentation.

2.3 Additional Features

The Mobexcom P25 DVRS also supports the following features:

- Extend and communicate with a trunked P25 system (as illustrated in Figure 1).
- Act as a stand-alone repeater with no communications to a trunked system. This is known as the "local mode" of operation.

[2] Pictures obtained from the *Mobexcom User's Guide*, Part No. 8A083X20, Rev. 0.
[3] Picture obtained from the *Mobexcom User's Guide*, Part No. 8A083X20, Rev. 0.

- Communicate with other DVRSs to create a network of DVRSs. It is possible for this DVRS network to communicate with a trunked P25 system that is operating in the same frequency band.
- Configuration as a cross-band system or an in-band system. The configuration must be decided upon before purchase of the system, and the system cannot be changed to operate in a different band later. See the tables on page 14 of the *Mobexcom User's Guide* (Part No. 8A083X20, Rev. 2), titled "In-Band DVRS Models" and "Cross-Band DVRS Models." They provide detailed information on the possible in-band and cross-band configurations.

2.4 Configurations

Table 3 shows the full-duplexed configurations Futurecom now supports, and the full-duplexed configurations planned for future support. The cross-band configuration was tested with the DVR operating in the 700 MHz band, and the XTL 5000 operating in the VHF band.

Table 3: Possible DVRS In-Band and Cross-Band Combinations

DVR Freq. Band (Local Side)	XTL 5000 Freq. Band (System Side)	Full-Duplexed DVRS Configuration Currently Available for Purchase (as of August 2006)	In-Band or Cross-Band Configuration
700 MHz	700 MHz	No	In-Band
800 MHz	800 MHz	No	In-Band
800 MHz	700 MHz	No	In-Band
700 MHz	800 MHz	No	In-Band
UHF	UHF	No	In-Band
VHF	VHF	Yes	In-Band
VHF	UHF	No	Cross-Band
VHF	700 MHz	No	Cross-Band
VHF	800 MHz	No	Cross-Band
UHF	VHF	No	Cross-Band
UHF	700 MHz	No	Cross-Band
UHF	800 MHz	No	Cross-Band
700 MHz	VHF	Yes	Cross-Band
700 MHz	UHF	No	Cross-Band
800 MHz	VHF	No	Cross-Band
800 MHz	UHF	No	Cross-Band

3 Mobexcom P25 DVRS Test Results

This section summarizes the results of all feature-based and specification-based test cases that were executed to evaluate the Mobexcom P25 DVRS.

The tests outlined in the sections that follow determine if the features advertised by the manufacturer conform to the document set, and summarize the test results. Each test identifies

the feature under test, the feature's test performance "state," the test description, and the feature's significance.

The "Pass, Fail, or Inconclusive" section of each test includes one of the following states to summarize how the feature performed compared to its description in the manufacturer's user guide:

- *Pass*. The feature performed as described in the manufacturer's user guide.
- *Pass with Exceptions*. The feature performed for the most part as described in the manufacturer's user guide.
- *Inconclusive*. Documentation discrepancies make it unclear whether the feature performed as the manufacturer described.
- *Fail*. The feature did not perform as the manufacturer described in the user guide.

A statistical summary follows. Out of the 51 tests executed:

- Three were assigned a status of "Inconclusive" (5.9 percent).
- Four were assigned a status of "Pass with Exceptions" (7.8 percent).
- 44 were assigned a status of "Pass" (86.3 percent).
- None were assigned a status of "Fail".

3.1 DVRS Power-Up Options

This section presents test case results for each DVRS power-up option.

3.1.1 DVRS Power Up: OFF Mode

Pass, Fail, or Inconclusive: Pass

Test Case Description: Based on the programmed personality, verify that the DVR can power up in the OFF mode state.

Significance: This feature is useful when a user wants the DVRS to be in the powered-up state, but not have the capability to engage with local- or system-side PSUs.

3.1.2 DVRS Power Up: On a Slaving-Enabled Channel

Pass, Fail, or Inconclusive: Pass

Test Case Description: Based on the programmed personality, verify that the DVR can power up in the OFF mode state.

Significance: This feature is useful when a user wants the DVRS to power up in a mode where the DVRS is ready to assist communications between local-side PSUs only, and the user requires that the DVR initially come up on a specific DVR channel.

3.1.3 DVRS Power Up: SYSTEM Mode (Last Selected DVR Channel)

Pass, Fail, or Inconclusive: Pass

Test Case Description: Based on the programmed personality, verify that the DVR can power up in the OFF mode state.

Significance: This feature is useful when a user wants the DVRS to power up in

a mode where the DVRS is ready to assist communications between local- and system-side PSUs, and where the user needs to immediately be on the DVR channel that was in use during the previous session.

3.1.4 DVRS Power Up: SYSTEM Mode (Preprogrammed DVR Channel)

Pass, Fail, or Inconclusive: Pass

Test Case Description: Based on the programmed personality, verify that the DVR can power up in the SYSTEM mode on the DVR channel that is preprogrammed.

Significance: This feature is useful when a user requires the DVRS to power up in a mode where the DVRS is ready to assist communications between local- and system-side PSUs, and the user requires that the DVR initially come up on a specific channel.

3.1.5 DVRS Power Up: LOCAL Mode (Last Selected DVR Channel)

Pass, Fail, or Inconclusive: Pass

Test Case Description: Based on the programmed personality, verify that the DVR can power up in the LOCAL mode on the DVR channel that was last selected.

Significance: This feature is useful when a user wants the DVRS to power up in a mode where the DVRS is ready to assist communications between local-side PSUs only, and where the user needs to be on the DVR channel that was in use during the previous session.

3.1.6 DVRS Power Up: LOCAL Mode (Preprogrammed DVR Channel)

Pass, Fail, or Inconclusive: Pass

Test Case Description: Based on the programmed personality, verify that the DVR can power up in the LOCAL mode on the DVR channel that is preprogrammed.

Significance: This feature is useful when a user wants the DVRS to power up in a mode where the DVRS is ready to assist communications between local-side PSUs only, and the user requires that the DVR initially come up on a specific DVR channel.

3.2 DVRS Status Display Features

This section presents test case results for each DVRS display feature.

3.2.1 DVRS Status Display: DVR Mode and Channel

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the DVRS current mode and channel alias are displayed on the top line (for example, “VR SYS CHAN1”).

Significance: This feature is useful so a user knows the mode the DVR is in, and to what channel it is currently tuned.

3.2.2 DVRS Status Display: DVR Status

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the DVR icon changes to indicate the DVRS status (master/slave/permanent master).

Significance: This feature is useful because the user can see the display of the current status of the DVRS (master, permanent master, or slave) in the O5 Control Head. This feature is important when a network of DVRSs has been configured.

3.2.3 DVRS Status Display: Right Arrow Indicator, Receiving

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that, when the DVR is receiving, the right-pointing arrow indicator appears in the O5 Control Head display.

Significance: This feature is useful because the current DVR status display in the O5 Control Head informs a user whether the DVR is currently receiving a transmission from a local-side PSU.

3.2.4 DVRS Status Display: Left Arrow Indicator, Transmitting

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that, when the DVR is transmitting, that the solid, right-pointing arrow indicator appears in the O5 Control Head display.

Significance: This feature is useful because the current DVR status display in the O5 Control Head informs a user whether the DVR is currently transmitting to local-side PSUs.

3.2.5 DVRS Status Display: Left and Right Arrow Indicator

Pass, Fail, or Inconclusive: Pass

Description: Verify that, when the DVR is transmitting and receiving, that the outlined left-pointing arrow indicator, and solid, right-pointing arrow indicator appear in the O5 Control Head display.

Significance: This feature is useful because the current DVR status display in the O5 Control Head informs a user whether the DVR is currently simultaneously receiving from and transmitting to local-side PSUs.

3.2.6 DVRS Status Display: VR ERROR

Pass, Fail, or Inconclusive: Pass

Test Case Description: When a DVR has detected an error, verify that the VR ERROR message appears in the O5 Control Head display.

Significance: This feature is useful because the current DVR status in the O5 Control Head informs a user whether the DVR is currently malfunctioning. This also informs the user that the DVR likely requires repair.

3.3 DVRS Tone Operation

This section presents test case results for the tone operation of the DVRS.

3.3.1 Talk Permit Tones Sent By DVR: Analog PSU

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an analog PSU, verify that the talk permit tones sent by the DVR are available and enabled in the DVRS.

Significance: The Go-Ahead tone allows a user of the local-side analog PSU to know that the system is available for use and is not busy.

3.3.2 DVRS OFF/SYSTEM/LOCAL Mode: DVRS Status Tones—MSU Speaker

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an XTS 5000 operating with a DVRS:

DVR OFF—Verify DVRS status tones at the MSU is disabled.

DVR SYSTEM—Verify DVRS status tones at the MSU is enabled.

DVR LOCAL—Verify DVRS status tones at the MSU is enabled.

Significance: This set of tones informs a user of the current state of the DVRS.

3.3.3 DVRS OFF/SYSTEM/LOCAL Mode: DVRS Status Tones PSU—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify the following using an XTS 5000 PSU with a DVRS:

DVR OFF—Verify DVRS status tones at the PSU is disabled.

DVR SYSTEM—Verify DVRS status tones at the PSU is enabled.

DVR LOCAL—Verify DVRS status tones at the PSU is enabled.

Significance: The Go-Ahead tone allows a user of the local-side XTS 5000 PSU to know that the system is available for use, and it is not busy.

3.4 DVRS Mode Operation

This section presents test case results for the mode operation of the DVRS.

3.4.1 OFF Mode Operation: MSU Receiving from System on Selected MSU TG/Channel

Pass, Fail, or Inconclusive: Pass

Test Case Description: While in the OFF mode, verify that the DVR doesn't repeat audio received by the MSU. The MSU speaker should emit audio.

Significance: This feature is useful when a user has not yet exited the vehicle or structure where the DVRS is located. This feature allows the user to passively monitor, or listen to, system-side activity.

3.4.2 DVRS Mode Selection: Mode Change by User Prohibited

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that, if the mode change by the user is prohibited in the specific DVRS personality, the user can still toggle the DVR Mode by pressing the VRS button and entering the DVR Control Mode.

Significance: This feature may be useful when it is desired to restrict a user's ability to change the mode of the DVR.

3.4.3 DVR Disabled Mobile Radio TGs/Channel

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that, when the user selects a "DVRS Disabled" TG/channel on the O5 Control Head, that a VR DISABLED message appears on the O5 display. Further verify that pressing the VRS button results in a DVR invalid option tone, and that the DVR operation is prohibited (that is, all functions are disabled).

Significance: It is important for a user to be aware of this feature. Without enabling this feature on the channel of interest in the MSU, DVR operation is not possible.

3.4.4 OFF Mode Operation: PSU Activity on DVR Channel

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the DVRS transmit function is disabled. The DVR shouldn't repeat, and there should be no speaker audio.

Significance: This feature is useful when a user wants to block local-side PSU communication, but desires to monitor system-side activity.

3.4.5 SYSTEM Mode Operation: MSU User PTTs the MSU Microphone

Pass, Fail, or Inconclusive: Inconclusive

Test Case Description: Verify that the DVR does not key up, and that the MSU does key up.

Significance: Based on the behavior observed, it is important a user understands that, when the MSU microphone is keyed up and the DVR is in SYSTEM mode, the transmission is not repeated to the local-side PSUs.

3.4.6 LOCAL Mode Operation: MSU Receiving from System on Selected MSU TG/Channel

Pass, Fail, or Inconclusive: Pass

Test Case Description: While in the OFF mode, verify that the DVR doesn't repeat audio received by the MSU. Speaker Audio is present.

Significance: This is a useful feature when a user wants local-side PSUs to monitor (listen to) system-side activity occurring on a given system-side TG.

3.4.7 LOCAL Mode Operation: MSU User PTTs the MSU Microphone

Pass, Fail, or Inconclusive: Inconclusive

Test Case Description: Verify that the DVR does not key up, and that the MSU keys up.

Significance: This feature might be useful when all local-side voice traffic needs to be funneled through a single individual. This individual would be the local-side PSUs' "representative" to the system-side PSUs and the dispatchers.

3.4.8 DVRS OFF Mode: Microphone PTT (MSU)

Pass, Fail, or Inconclusive: Inconclusive

Test Case Description: For the DVRS MSU (Motorola XTL 5000), verify that the DVR, when in OFF mode, does not key up and that the MSU keys up.

Significance: This feature might be useful when a user is in a vehicle and there are no local-side PSUs with which to communicate. The user can communicate with system-side users.

3.5 Extension of Trunked System Features via the DVRS

This section presents test case results for each DVRS extension of a trunked system feature.

3.5.1 Registration via the DVRS

Pass, Fail, or Inconclusive: Pass

Test Case Description: For the XTS 5000, verify that the registration feature is passed by the DVRS to the trunked system (DVRS = Digital Vehicular Repeater interfaced to an XTL 5000 MSU with an O5 Control Head).

Significance: The fact that a local-side PSU can register with the trunked system is significant. It demonstrates that the DVRS is extending the range of the trunked system.

3.5.2 De-Registration via the DVRS

Pass, Fail, or Inconclusive: Pass

Test Case Description: For the XTS 5000, verify that the DVRS passes the de-registration message to the trunked system.

Significance: The fact that a local-side PSU can de-register from the trunked system is significant. It demonstrates that the DVRS is acting to extend the range of the trunked system.

3.5.3 DVRS OFF/SYSTEM/LOCAL Mode: PSU Affiliation—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: Affiliation is the process of joining a TG. Verify the following using an XTS 5000 PSU:

DVR OFF—PSU affiliation is disabled/not available.

DVR SYSTEM—PSU affiliation is enabled.

DVR LOCAL Mode—PSU affiliation is enabled.

Significance: This feature demonstrates that the coverage of the trunked system is being extended to the local-side PSUs.

3.5.4 DVRS OFF/SYSTEM/LOCAL Mode: Radio Inhibit—XTS 5000

Pass, Fail, or Inconclusive: Pass with Exceptions

Test Case Description: Verify the following for an XTS 5000 operating with a DVRS:

DVR OFF—Verify that Radio Inhibit is disabled.

DVR SYSTEM—Verify that Radio Inhibit is enabled.

DVR LOCAL—Verify that Radio Inhibit is enabled.

Significance: The radio inhibit function is useful when a local-side PSU has been stolen or lost, and it needs to be disabled.

3.5.5 DVRS OFF/SYSTEM/LOCAL Mode: Radio Check—XTS 5000

Pass, Fail, or Inconclusive: Pass with Exceptions

Test Case Description: Verify the following for an XTS 5000 operating with a DVRS:

DVR OFF—Verify that Radio Check is disabled.

DVR SYSTEM—Verify that Radio Check is enabled.

DVR LOCAL—Verify that Radio Check is enabled.

Significance: The radio check function is useful when a dispatcher wants to identify, or obtain information related to, a given local-side PSU.

3.5.6 System Status Reporting: Out of Range

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the Out of Range reporting function is passed to the PSUs through the DVRS—only when SYSTEM mode is selected, and only when an XTS 5000 is used.

Significance: This feature is useful when initially setting up the DVRS in the field. This message tells users whether they can establish a link with the trunked system.

3.6 Outbound (System to DVRS) Feature Operation

This section presents test case results for each system to DVRS feature.

3.6.1 DVRS OFF/SYSTEM/LOCAL Mode: Outbound Group Call—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify the following for an XTS 5000 operating with a DVRS:

DVR OFF—Verify that the Outbound Group Call (from the trunked system to DVRS) is disabled.

DVR SYSTEM—Verify that the Outbound Group Call is enabled.

DVR LOCAL—Verify that the Outbound Group Call is enabled.

Significance: This test case demonstrates the ability of the DVRS to extend a group call that originates at a system-side PSU to local-side PSUs.

3.6.2 DVRS OFF/SYSTEM/LOCAL Mode: Outbound Private Call—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify the following using an XTS 5000 PSU with a DVRS:
DVR OFF—Verify that the Outbound Private Call is disabled.
DVR SYSTEM—Verify that the Outbound Private Call is enabled.
DVR LOCAL—Verify that the Outbound Private Call is enabled.

Significance: This test case demonstrates the ability of the DVRS to extend a private call that originates at a system-side PSU to a local-side PSU.

3.6.3 Outbound Call Alert:: DVRS in LOCAL Mode

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify the DVRS passes system-side PSU outbound call alerts when the destination local-side XTS 5000 PSU is affiliated through the DVRS.

Significance: This feature is useful when a system-side user wants to page another local-side user, even though the DVRS is in LOCAL mode.

3.6.4 DVRS Outbound Encrypted Call (SYSTEM and LOCAL Modes)

Pass, Fail, or Inconclusive: Pass

Test Case Description: For the XTS 5000 PSU, verify the DVRS passes encrypted calls from a system-side PSU to a local-side PSU.

Significance: This feature is useful if encrypted transmission is required between a system-side user and certain local-side users.

3.7 Inbound (DVRS to System) Feature Operation

This section presents test case results for each DVRS to system feature.

3.7.1 DVRS OFF/SYSTEM/LOCAL Mode: Inbound Group Call—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an XTS 5000 operating with a DVRS, verify the Inbound Group Call feature:
DVR OFF—Verify that the Inbound Group Call is disabled.
DVR SYSTEM—Verify that the Inbound Group Call is enabled.
DVR LOCAL—Verify that the Inbound Group Call is enabled.

Significance: This test case demonstrates the ability of the DVRS to extend a group call that originates at a local-side PSU to system-side PSUs.

3.7.2 DVRS OFF/SYSTEM/LOCAL Mode: Inbound Private Call—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an XTS 5000 operating with a DVRS, verify the Inbound Private Call feature:

DVR OFF—Verify that the Inbound Private Call is disabled.

DVR SYSTEM—Verify that the Inbound Private Call is enabled.

DVR LOCAL—Verify that the Inbound Private Call is enabled.

Significance: This test case demonstrates the ability of the DVRS to extend a private call that originates at a local-side PSU to a system-side PSU.

3.7.3 DVRS OFF/SYSTEM/LOCAL Mode: Inbound Call Alert—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an XTS 5000 operating with a DVRS, verify the Inbound Call Alert feature:

DVR OFF—Verify that the Inbound Call Alert is disabled.

DVR SYSTEM—Verify that the Inbound Call Alert is enabled.

DVR LOCAL—Verify that the Inbound Call Alert is enabled.

Significance: This feature is useful when one user wants to page another local- or system-side user.

3.7.4 DVRS OFF/SYSTEM/LOCAL Mode: Inbound Emergency Alarm—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an XTS 5000 operating with a DVRS, verify the Inbound Emergency Alarm feature:

DVR OFF—Verify that the Inbound Emergency Alarm is enabled.

DVR SYSTEM—Verify that the Inbound Emergency Alarm is enabled.

DVR LOCAL—Verify that the Inbound Emergency Alarm is enabled.

Significance: This is a useful feature when the user is in a critical situation, and doesn't have the ability or time to send a voice transmission.

3.7.5 DVRS OFF/SYSTEM/LOCAL Mode: Inbound Emergency Call—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an XTS 5000 operating with a DVRS, verify the Inbound Emergency Call feature:

DVR OFF—Verify that the Inbound Emergency Call is enabled.

DVR SYSTEM—Verify that the Inbound Emergency Call is enabled.

DVR LOCAL—Verify that the Inbound Emergency Call is enabled.

Significance: This is a useful feature when a local-side user is in a critical situation, and needs to have voice transmission processed by the trunked system to dispatchers or other system-side PSUs.

3.7.6 DVRS Inbound Encrypted Call (SYSTEM and LOCAL Modes)

Pass, Fail, or Inconclusive: Pass

Test Case Description: For the XTS 5000 PSU, verify the DVRS passes encrypted calls from a local-side PSU to a system-side PSU.

Significance: This feature is useful if encrypted transmission is required between a local-side user and certain system-side users, or from a local-side user to other specific, local-side users.

3.8 DVRS Automatic and Remote Feature Operation

This section presents test case results for each DVRS automatic and remote feature.

3.8.1 Remote Call Control via Emergency Call

Pass, Fail, or Inconclusive: Pass

Test Case Description: For the XTS 5000 PSU, verify that, when the DVR is in OFF mode and it receives an emergency call from a local PSU, the DVR will switch to SYS mode and process the emergency call to the system.

Significance: This feature is useful when a local-side user is in a critical situation, and requires communication with system-side users and dispatchers.

3.8.2 Auto De-Activation of DVR via Inactivity Timer

Pass, Fail, or Inconclusive: Inconclusive

Test Case Description: Verify that the DVR can switch automatically to OFF mode upon expiration of its Inactivity Timer (programmable from 0 to 180 minutes). The timer is restarted every time the DVR detects PSU activity.

Significance: This feature is useful if the user requires that the DVR turn off after a certain number of minutes.

3.8.3 DVR Automatic Entry

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the DVR automatically enters the pre-programmed DVR mode/channel associated (“slaved”) with the selected MSU TG/channel if the DVR is programmed as a slave.

Significance: This feature is useful because a certain DVR mode and channel are always required when the MSU is tuned to a given TG. The feature creates a permanent association in the DVR to link these entities. This feature could reduce the burden of users having to remember all of the possible combinations of MSU TG, DVR mode, and DVR channel.

3.8.4 DVRS OFF/SYSTEM/LOCAL Mode: Remote Control (Steering) of DVR—XTS 5000

Pass, Fail, or Inconclusive: Pass

Test Case Description: For an XTS 5000 operating with a DVRS, verify the remote control feature:

DVR OFF—Verify that the DVRS steering is enabled.

DVR SYSTEM—Verify that the remote PSU steering capability is enabled.

DVR LOCAL—Verify that local-side PSU steering of the DVRS is enabled.

Significance: This feature could be useful to a local-side user in the field who has no access to the O5 Control Head, but who needs to control the DVR mode and TG.

3.9 DVRS Specification Tests

This section presents test case results for each DVRS specification.

3.9.1 Programmable Power Output

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the power out of the repeater can be programmed between 0.1 W to 10 W.

Significance: The user can adjust the output power of the DVR to maintain communications with local-side PSUs, depending on the size of the geographic coverage area.

3.9.2 Transmitter Audio Response: Analog Mode

Pass, Fail, or Inconclusive: Pass with Exceptions

Test Case Description: Verify that the transmitter audio response is +1, -3dB of 6dB per octave pre-emphasis. This is the characteristic over the range of 300Hz to 3KHz.

Significance: This test ensures that the device is transmitting signals in the audible band (300 Hz to 3 KHz) at the correct power level, which ultimately affects the quality of the audio the user hears.

3.9.3 Transmitter Audio Distortion: Analog Mode

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the audio distortion due to the transmitter is less than 2 percent.

Significance: Test results show that the transmitted audio does not experience significant distortion, thereby minimizing the impact on voice quality.

3.9.4 Receiver Sensitivity: Analog Mode

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the receiver sensitivity is -115 dBm (0.32uV).

Significance: The test case verified that the DVR's receiver sensitivity conforms to the vendor's specification.

3.9.5 Receiver Intermodulation: Analog Mode

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the intermodulation at the receiver is 75 dB.

Significance: The test case verified that the DVR's intermodulation level conforms to the vendor's specification.

3.9.6 Receiver Frequency Deviation: Analog Mode

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the receiver frequency deviation for a 12.5000Hz channel is +/- 2.5 KHz.

Significance: The test case verified that the DVR's frequency deviation conforms to the vendor's specification.

3.9.7 Receiver Audio Response: Analog Mode

Pass, Fail, or Inconclusive: Pass with Exceptions

Test Case Description: Verify that the receiver audio response is +1, -3dB of 6dB per octave pre-emphasis. This is the characteristic over the range of 300Hz to 3KHz.

Significance: The test case verified that the DVR's transmitter frequency response conforms for the most part to the vendor's specification. This test ensures that the DVR can receive, demodulate, and render baseband signals at the correct power level, which ultimately affects user-heard audio quality.

3.9.8 Receiver Audio Distortion: Analog Mode

Pass, Fail, or Inconclusive: Pass

Test Case Description: Verify that the audio distortion due to the transmitter is less than 2 percent.

Significance: This test gives the end user confidence that the received audio does not experience significant distortion, thereby minimizing the impact on voice quality.

3.9.9 RF Emissions

Pass, Fail, or Inconclusive: Not Applicable. This is an observation and is not a vendor-published specification.

Test Case Description: The purpose of this test is to determine if the DVRS introduces into the environment a significant amount of RF energy.

Significance: Test results showed no emissions of significance. This indicates the DVRS most likely will not interfere with the operation of other electronic devices. (Refer to the section on RF emissions below.)

4 Observations Made During Product Evaluation

This section identifies behavior observed during the evaluation of the DVRS that may interest public safety organizations. The observations pertain to:

- RF emissions
- Document set discrepancies
- Computer requirements for setup
- Manufacturer responsiveness

4.1 RF Emissions

Because the Mobexcom P25 DVRS must operate in environments with other RF equipment, an informal RF emissions scan was made in the 20 MHz to 500MHz range. The results of this test showed that it is very unlikely that the Mobexcom P25 DVRS will interfere with other electronic devices in its vicinity. Note that this was not a formal compliance test, only an observation.

4.2 Document Set Discrepancies

As mentioned previously, the vendor document set consists of three documents:

- *Mobexcom P25 DVRS Installation & Programming Guide*, Part No. 8M083X01, Rev. 1
- *Mobexcom P25 Digital Vehicular Repeater User's Guide*, Part No. 8A083X20, Rev. 0
- *Mobexcom P25 Functional Description*, Part No. 8K083X01, Rev. 3

Because the functionality of some features was not consistently described across all three documents, a status of "Inconclusive" was assigned to several tests. A status of "Pass with Exceptions" was assigned for four features because only part of the test case failed, not the entire test. Several test cases contained up to three independent sub-tests; it would have been unfair to fail the entire test case. The test case results do note, however, which sub-test failed. Tests that failed were those where the feature description was consistent across all the document set, but the feature under test did not perform as described in the document set.

4.3 Computer Requirements for Setup

The DVRS is generally configurable and usable through the O5 Control Head. However, initial setup and configuration programming requires use of the Tweaker software, running on a user-supplied Microsoft Windows computer connected to the USB port of the DVRS. A user-supplied Microsoft Windows computer with the Motorola CPS software is also required to program the MSU (XTL 5000) and PSUs. A special cable (USB to round) from Motorola, Inc. is required to connect the MSU and the PC. A special PSU vendor-specific cable is also required to connect the PSU and the PC.

4.4 Manufacturer Responsiveness

During the testing period, the vendor was called several times for assistance regarding configuration of various DVRS features. The vendor was very willing to help, and testing was not affected in a negative way. The vendor even sent an engineer on-site, at no additional cost, to assist with some of the specification-based tests.

Appendix A: Glossary of Terms and Acronyms

Channel—A group of characteristics, such as transmit-and-receive frequency pairs, radio parameters, encryption encoding, etc.

Conventional radio communications—Refers to radio-to-radio communications, sometimes through a base station repeater or vehicular repeater

dB—Decibels

DHS—U.S. Department of Homeland Security

Dispatcher—An individual who has radio system dispatch duties

DVR—Digital Vehicular Repeater

DVR ID—Programmable (in the DVR) ID, which is used for mode and TG steering. To remotely change the mode and TG on the DVRS, the PSU user sends a call alert page to the specific DVR ID.

DVR Mode—Determines the communication exchange capabilities between system-side users and local-side PSUs; can be set to OFF, LOCAL, or SYSTEM.

DVRS—Digital Vehicular Repeater System, interfaced to an XTL 5000 Mobile radio with an O5 Control Head

FCC—Federal Communications Commission

FFT (Fast Fourier Transform)—A computationally efficient means of computing the frequency content of a waveform

Inbound Call—Local-side, PSU-originated call received by the DVR

LMR (Land Mobile Radio)—A common descriptor of the type of radio communication system that public safety practitioners frequently use

Local Mode—DVR mode which provides extended PSU-to-PSU voice and data range. It does this by repeating local-side PSU (optionally MSU) communications without keying up the MSU interfaced to the DVR

Mode MSU or PSU—A programmed combination of operating parameters. DVR: OFF, SYSTEM, or LOCAL (see DVR Mode)

MSU—Mobile Subscriber Unit

NIST—National Institute of Standards and Technology, an agency of the U.S. Department of Commerce's Technology Administration

O5 —Odyssey 5 Control Head using CAN bus (Controller Area Network bidirectional universal switch)

OIC—The Office of Interoperability and Compatibility within the DHS Science and Technology (S&T) Directorate

OLES—The Office of Law Enforcement Standards within NIST

Outbound Call—System call received by the MSU

P25—Project 25

Phase I—First DVR and XTL5000 Firmware Release: Target Release Date of Q1 2006.

Phase II—Second DVR and XTL5000 Firmware Release: Target Release Date of Q4 2006.

PSU—Portable Subscriber Unit

PTT—Push-to-talk. The PTT engages the transmitter (of the PSU or MSU and/or DVR) when pressed

RF—Radio Frequency. Part of the general frequency spectrum 10 kHz to 10,000,000 MHz

RSSI—Received Signal Strength Indicator

S&T—Science and Technology Directorate of DHS

SINAD—The ratio of Signal + Noise + Distortion to Noise + Distortion

System Mode—DVR mode which provides extended voice and signaling communications between system-side users and local-side PSU users over the selected DVR channel and mobile radio mode

Talk Group (or TG)—A group of radio users who communicate with each other by using the same communication path

THD+N—The sum of the Total Harmonic Distortion plus Noise. THD is the ratio of the power of all harmonic frequencies introduced by a system to the power of the fundamental frequency to which the frequencies are added.

Trunking—The automatic sharing of radio frequencies by a large number of users based on communication path sharing for the length of a conversation

UHF (Ultra High Frequency)—Frequencies from 300 MHz to 3,000 MHz

USB—Universal Serial Bus

VHF (Very High Frequency)—Frequencies from 30 MHz to 300 MHz

Vp—Peak voltage

Vpp—Peak-to-peak voltage

VR—Vehicular repeater

XTL 5000—Motorola XTL 5000 mobile subscriber unit

XTS 5000—Motorola XTS 5000 portable subscriber unit