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Operational Test Bed—Alexandria (OTB-A) Communications Interoperability Gateway Subsystem Operational Test Document

Advanced Generation of Interoperability for Law Enforcement (AGILE)

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National Law Enforcement and Corrections Technology Center—Northeast
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1. INTRODUCTION

This document details the results of tests conducted to verify proper operation of a communications interoperability Gateway Subsystem based on an ACU-1000 Intelligent Interconnect System. This Subsystem has been installed at the Alexandria, Virginia, Police Department (APD), and interfaced with the existing communications infrastructure of the APD and other law enforcement and public safety agencies in the metropolitan Washington, D.C., region. The resulting communications interoperability capability allows direct voice over-the-air radio communications among multiple law enforcement agencies that utilize radio systems operating in different frequency bands, or operating within the same frequency band but using incompatible modulation formats or trunking techniques that defeat interoperability.

1.1. AGILE Operational Test Bed

The creation of this communications interoperability capability is part of the Advanced Generation of Interoperability for Law Enforcement (AGILE) program. The AGILE program is a major commitment by the National Institute of Justice (NIJ) to address the issues of interoperability that hamper effective and efficient cooperation among multiple law enforcement and other public safety agencies. Interoperability issues appear in various ways: communications systems that cannot support inter-agency communications, information that is not accessible by all agencies who need it, and open case and suspect information maintained by one agency that is unknown by other agencies working on related cases. The AGILE program is a broad-based set of activities to address the varied aspects of the interoperability challenge, organized into three major thrust areas:

1) Research, development, test, and evaluation (RDT&E);
2) Standards identification, development, and adoption; and
3) Outreach and technical assistance.

A key component of the AGILE RDT&E thrust area is an Operational Test Bed (OTB) in a public safety environment to integrate, test, and evaluate technologies that can contribute to addressing interoperability needs. For an OTB, candidate technology solutions to specific interoperability requirements such as voice over-the-air interoperability, data transmission interoperability, data sharing, and data analysis are categorized and evaluated. The evaluations include quantitative performance measurements as well as qualitative evaluations of the impact of the technology on law enforcement agency operations.

NIJ has partnered with APD to be the focal point of an OTB, with technical and systems engineering support provided by the National Law Enforcement and Corrections Technology Center—Northeast (NLECTC-NE). Over-the-air radio communications among multiple agencies is the first interoperability requirement addressed in this OTB.

1.2. Scope of this Document

This Test Document is one of a set of documents concerning the Gateway Subsystem. The Operational Concept Document (document 1 referenced below) defines the problem that the Gateway Subsystem is designed to address. The System Description Document (document 2 referenced below) provides a description of the Gateway Subsystem. This document outlines the plan for performing and documents the results of tests on the Gateway Subsystem to ensure proper functioning prior to beginning operational use.

The tests include functional and operational tests. The functional tests were designed to check out the communication links by performing radio checks with participating agency dispatch units and deployed patrol units. Operational Tests #1 and #2 were scripted tests simulating operational scenarios involving the participating agencies. Based on the data collected in the execution of those tests, several modifications were made to the Gateway Subsystem configuration. The exercises were re-run as Operational Tests #3 and #4. Descriptions of these tests are provided along with documentation of the results.

This document serves two purposes. First, it captures a record of the executed tests and resulting modifications to the Gateway Subsystem. In addition, the layout of the tests may be useful as a template to other agencies planning functional and/or operational tests of interoperability technologies and systems.

1.3. Document Overview

A brief description of the Gateway Subsystem is provided in Section 2. An overview of the tests is provided in Section 3. Section 4 includes a description of the activities that were undertaken in preparation for test execution. A summary of the test results is provided in Section 5. Section 6 includes a description of each test, a narrative of the results of the test, and any changes that were made to the Gateway Subsystem as a result of the test. Four appendices are also included:

- Appendix A is a detailed discussion of the "ping pong" effect, which presented the most difficult technical challenge in optimizing performance of the Gateway Subsystem;
- Appendix B includes reference information for ACU-1000 parameters;
- Appendix C includes a detailed description of the Functional Test, including the full script and documentation of the results of each individual test sequence; and
- Appendix D contains a log file generated by the ACU-1000 showing the interconnections made during the course of the Functional Test.

1.4. References and Manuals

The following are used as references in these procedures:

1. *Operational Test Bed—Alexandria (OTB-A) Communications Interoperability Gateway Subsystem Description Document*, AGILE Report No. TE-00-01.
2. *Operational Test Bed—Alexandria Communications Interoperability Capability Operational Concept*, AGILE Report No. TE-00-03, currently in draft form.
3. *ACU-1000 Installation and Operation Manual*, Revision 2.1, October 1999, by JPS Communications, Inc., Raleigh NC.
4. *TRP-1000 System Operation Manual*, Revision 1.2, December 1999, JPS P/N 5970-800200, JPS Communications, Inc., Raleigh NC.

5. Equipment manuals for each Mobile radio model (MCS2000, Astro Spectra).
6. *Initial Lessons Learned in Testing and Deploying the ACU-1000*, AGILE Technical Memorandum, 15 June 2001.

2. GATEWAY SUBSYSTEM OVERVIEW

The Gateway Subsystem installed at the Alexandria Police Department is a fixed-site permanent installation, thereby providing interoperability as part of the daily operations of the participating agencies. This Gateway Subsystem provides connectivity among the radio systems of APD and other agencies participating in this initiative, accommodating the fact that these systems operate at different frequency bands (VHF, UHF, and 800 MHz).

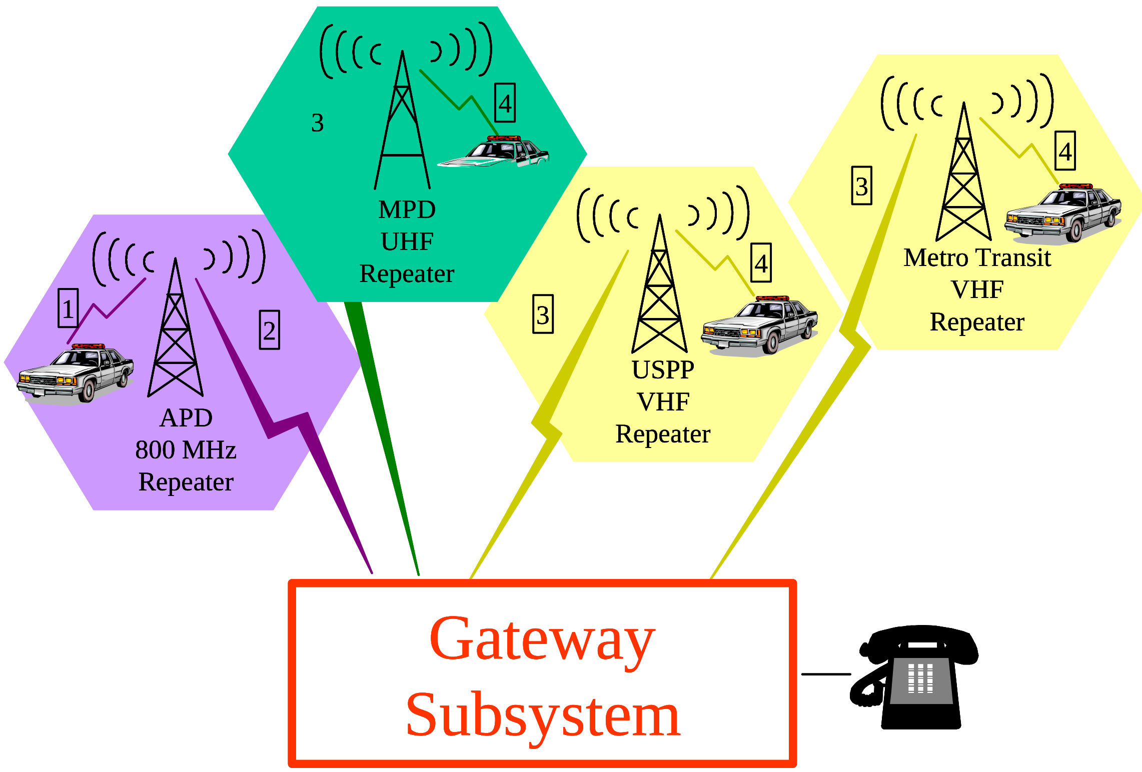

Figure 1: Gateway Subsystem Concept

As shown in Figure 1, when a connection is established among channels of the participating agencies, a transmission from an APD officer (1) is picked up by the APD repeater and broadcast to all APD units (2) and is also received by the Gateway Subsystem. The audio is then rebroadcast on the frequencies of the other participating agencies (3). The agencies' repeater sites receive the transmission and broadcast out to the radios of the respective agencies (4).

The Gateway Subsystem includes: antennas, radios, the ACU-1000, a PC-based graphical user interface (GUI) located with the ACU-1000, a dispatch supervisor's console (consisting of the same GUI and an audio unit), and the cabling necessary to connect these components.

The heart of the Gateway Subsystem is the ACU-1000 Intelligent Interconnect System, a commercial product developed by JPS Communications, Inc., of Raleigh, North Carolina. The ACU-1000 is a modularized approach to interconnecting various types of communications systems, including land mobile radios. Its basic components include the following:

- Interface modules, each designed to connect communications media such as radios or telephones;
- A control module;

- A power supply module;
- A local operator interface module;
- A chassis to accommodate the modules, and
- A backplane to route audio and control signals between modules.

For each radio system being connected by the ACU-1000, a radio is integrated into the unit through an interface module. The interface modules convert communications traffic into its essential elements: receive and transmit audio, and non-proprietary and/or industry-standard accessory port control signals (required to control the device to which the module is interfacing). Software to control the unit includes an intuitive user interface to connect and disconnect the radios integrated into the unit. Voice prompts give users audible instructions for establishing connections. Setting up connections can be done remotely using standard Dual Tone Multi-Frequency (DTMF) tones such as from a telephone or radio DTMF keypad. Local control is provided using the operator interface module, or using the software interface program running on a PC.

Each radio is connected to an antenna mounted on the roof of APD's headquarters building. The radios are programmed with frequencies licensed to the participating agencies. Typically, the radios are set to a default channel that a participating agency designates for inter-agency communications. Radio channels may be switched manually as required to transmit and receive on a different frequency channel, or to accommodate a different participating agency. For example, the second 800 MHz radio (currently programmed to interface with APD) provides immediate expansion to accommodate additional participating agencies with 800 MHz radio systems and a repeater within coverage range of the Gateway Subsystem.

3. TEST OVERVIEW

3.1. Test Objective

The primary objective of these tests is to ensure that the Gateway Subsystem functions sufficiently well to begin use in multi-agency training exercises. These tests are not a comprehensive evaluation of all equipment functionality, but rather a set of progressively more involved tests to ensure that radio-to-radio over-the-air communications across agency radio systems could be accomplished through the Gateway Subsystem.

Key issues to be addressed in these tests include:

- Communication: Ensure that the Gateway Subsystem can communicate with dispatch centers and field officers of the participating agencies.
- Control: Ensure that connections can be created and terminated through the ACU-1000 console.
- Interoperability: Ensure that the connections established through the ACU-1000 allow communications among radios operating on different radio systems.
- Voice Quality: Ensure that the communications can be understood, and without unacceptable delays.

These tests are organized into sets that progressively test the capabilities of the subsystem. The tests are as follows:

- Functional Test:
  - ♦ Receive only tests – no links;
  - ♦ Receive only, audio link to PSTN-1, no transmissions;
  - ♦ Transmission tests to a non-operational channel;
  - ♦ Transmission tests to communications centers, no links;
  - ♦ Transmission tests direct to field units, no links;
  - ♦ Test links and unit to unit transmissions;
  - ♦ Test link within same band (USPP – Metro Transit); and
  - ♦ Link multi-bands with units side by side.
- Operational Tests:
  - ♦ Follow the Leader (Operational Tests #1 and #3); and
  - ♦ Traffic Control (Operational Tests #2 and #4).

3.2. Test Location and Participants

The tests were coordinated by personnel located in the equipment room of the dispatch center of APD, located at 2003 Mill Road, Alexandria, Virginia. Representatives of the following agencies participated in the tests:

- Alexandria Police Department (APD);

- Metropolitan Police Department, Washington, DC (MPD);
- United States Park Police (USPP); and
- Metro Transit Police Department, Washington Metro Area Transit Authority (Metro).

Representatives of these agencies were also located in vehicles deployed in their respective jurisdictions. Representatives of NIJ and the NLECTC-NE were also present at APD to observe.

Tests were performed periodically beginning in late July, 2000. Specific times and dates are listed in Table 1.

Table 1: Operational Test Times

Test	Date	Time
Functional Test	21 July 2000	0500
Operational Test #1	28 August 2000	0500
Operational Test #2	11 September 2000	0500
Operational Test #3	2 October 2000	0500
Operational Test #4	20 October 2000	2200

3.3. Recording of Results

A video camera was set up to record activities at the ACU-1000 console during the Functional Test. Audiotapes were used to record the other tests. The video and audio tapes and observers' notes are the basis of the results documented in this report.

The ACU-1000 also maintains a log of the connections that are made among its component interface modules. Each connection or disconnection is recorded along with a time stamp.

4. TEST PREPARATIONS

There were a number of activities that were accomplished prior to conducting the tests, including the following:

- Installation of the Gateway Subsystem;
- Programming of radios in the Gateway Subsystem;
- Training;
- Planning and coordination; and
- Setting up test recording equipment.

Each of these activities is described in a paragraph that follows.

The Gateway Subsystem was installed with its appropriate cabling, grounding, and power, as described in the Gateway Subsystem Description Document (reference document #2). Test personnel performed a visual inspection of the equipment installation before beginning these tests. The ACU-1000 was configured and operated according to the Installation and Operation Manual (reference document #4). The revision numbers (assigned by the manufacturer) of the hardware and software versions of the specific ACU-1000 unit used in the tests are shown in Table 2.

Table 2: ACU-1000 Hardware/Software Configuration

Module	Description	Quantity	Hardware Revision	Software Revision
PSM-1	60W Power Supply Module	1	A	N/A
HSP-2	Handset and Speaker Module	1	C	U34 1069-123 105 U4 1069-180 100 U5 1096-1981 400
CPM-2	Control Processor Module (System "Brain")	1	E	U4 1096-124 105 U5 V62C5181025L
PSTN-1	Interface to Telephone Network	1	C	U8 S/W 1096-201 211
DSP-1	Digital Signal Processor (Radio Interface)	6	E	U8 S/W 1096-201 203

Parameters settings for the ACU-1000 are shown in Table 3. Settings for the DSP (radio interface cards) are shown in Table 4. Parameters changed from the factory defaults are shown in the table with a blue (dark) background. As part of the installation, the Gateway Subsystem was exercised, and the Transmit (Tx), Receive (Rx), and Carrier Operated Relay (COR) Inhibit times were changed from factory default settings to improve performance. For the actual test, the 800 MHz radio interfaced to DSP slot number 2 was not used (because the trunking capability had not been activated and therefore the radio was only usable in a talk around mode). Parameter values in used in Table 3 are defined in Appendix B.

Table 3: ACU-1000 Main Module Settings

Hardware :

Main Chassis Rear Panel	Designator	Factory Setting	Current Setting
AC Line Voltage 110V/220V AC nominal	AC Line Input Module	Set for Voltage at Customer Site	110 V
Power Supply Module	**Designator**	**Factory Setting**	**Current Setting**
DC Supply Voltage +12V/+24V DC	SW2	+24V	+24V
Charger On/Off	SW3	Off	Off
HSP-2 Module Configuration	**Designator**	**Factory Setting**	**Current Setting**
Internal/External Speaker Selection	JP-1	Internal Speaker Enabled	Internal Speaker Enabled
CPM-2 Module Configuration	**Designator**	**Factory Setting**	**Current Setting**
Serial Port Baud Rate	SW1-1, 2	9600	9600
Remote Control Enable/Disable	SW1-3	Enabled	Enabled
Serial Sync Character Requirement	SW1-4	Not required	Not required
Reserved for future use	*SW1-5*	*Off*	*Off*
Chassis Configuration (Single Chassis or place in Expanded System)	SW1-6, 7	Single Chassis	Single Chassis
Manufacturing Test Enable/Disable	SW1-8	Disabled	Disabled
Reserved for future use	*All of SW-2*	*Off*	*Off*

Software :

System Programming (CPM2)	Command	n = Selection	Factory	Current Setting
Enter Programming mode	* 9 9	None	N/A	N/A
Console Override	* 3 7	None	N/A	N/A
Select Module to Program	* 0 1 n n	n n = slot extension (two digits must be entered).	N/A	N/A
Exit Programming Mode	* #	None	N/A	N/A
Reset Modules to Factory Settings	* 9 9 9 9	None	N/A	N/A
Enable System PINs	* 2 9 n	0 = ***Disable*** PINs 1 = Enable PINs in Priority operation, 2 = Enable PINs in Exclusive operation	***Disabled***	***Disabled***
Program PINs	* 3 0 nnnnx	Nnnn is the four digit PIN, x is the security level from 0 to 9, 0 = not secure (PIN not required), 1=least secure, 9 = most secure.	PIN Database Cleared	PIN Database Cleared
Delete PINs	* 3 1 nnnn	Nnnn is the four digit PIN	N/A	N/A
HSP-2 Programming	**Command**	**n = Selection**	**Factory**	**Current Setting**
Voice Prompt Initiation Delay	* 4 4 n	0 = ***No Delay***, 1 = 50 ms, 2 = 100 ms, 3 = 500 ms, 4 = 750 ms, 5 = 1 sec, 6 = 2 sec, 7 = 3 sec, 8 = 4 sec, 9 = 5 sec	***No Delay***	***No Delay***

Table 4: DSP Settings for the Functional Test

DSP Slot	1	2	4	5	6	7
Radio Type	800 MHz Digital Trunked	800 MHz Digital Trunked	450 MHz MCS2000	450 MHz MCS2000	150 MHz MCS2000	150 MHz MCS2000
DSP Module Name	APD	800	UHF	MPD	WMATA	USPP
TX Level	3	3	3	3	3	3
RX Level	6	6	6	6	6	6
Squelch Type	VOX	VOX	VOX	VOX	VOX	VOX
VOX/VMR threshold	1	1	1	1	1	1
DTMF Mute Timer	2	2	2	2	2	2
Security Level	0	0	0	0	0	0
VOX/VMR Hangtime	1	1	1	1	1	1
Audio Equalizer	0	0	0	0	0	0
Positive/Negative COR	Negative	Negative	Negative	Negative	Negative	Negative
COR Sampling Enabled/Disabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Audio Delay Time	1	1	1	1	1	1
Half/Full Duplex	Half	Half	Half	Half	Half	Half
COR Sampling Initial Delay Time	4	4	4	4	4	4
COR Sampling Interval	4	4	4	4	4	4
Squelch On/Off	On	On	On	On	On	On
COR Sampling Width	2	2	2	2	2	2
Keying T	0	0	0	0	0	0
PTT/COR Priority	PTT	PTT	PTT	PTT	PTT	PTT
Peaker Value	0	0	0	0	0	0
COR Inhibit Time	5	5	5	5	5	5
Keying	1	1	1	1	1	1
DTMF Command Disabled/Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Out Control User/Local	Local	Local	Local	Local	Local	Local
Radio Type	1	0	0	0	0	0

All radios used in performing functional evaluations were programmed to the frequencies and operational parameters (i.e., modulation) licensed to the participating agencies, as shown in Table 5.

Table 5: Channels Programmed into Radios

Radios (identified by DSP Slot)	Agency	Channels
1 and 2	APD	Main OPS-2 OPS-3 Zebra National Calling Channel NTact1 NTact2 NTact3 NTact4
4 and 5	MPD	Command City Wide 1 SOD 1D 2D 3D 4D 5D 6D 7D
6 and 7	USPP	USPP 1 (Backup) Channel 2 Main Tact 3
	Metro Transit	Metro Transit
	Weather	Weather

An interagency working group was established to plan the tests and to coordinate test activities with the participating agencies. The Chiefs of each participating agency designated representatives. The working group representatives assisted in defining test procedures and schedules. Tests were scheduled to minimize interference with daily agency operations. Each agency's dispatch center was notified of the general nature and time of the tests.

Personnel working with the Gateway Subsystem itself during these tests were familiar with the basic operations of the ACU-1000. The primary operator was a uniformed officer of APD. Some test personnel also attended a two-day training course provided by the manufacturer of the ACU-1000. However, agency dispatch operators were not provided any training on the ACU-1000, nor were field officers given any direction as to how to conduct the radio checks. The scripts were not made available to dispatcher operators or field officers either.

To record the results of the functional test, a video camera was set up in the equipment room where the ACU-1000 was located, and a videotape was made of the tests. For all Operational Tests, since all of APD's channels are recorded digitally, the digital recording was downloaded and brought into the equipment room where there is a digital player. Audio tapes for post-test analysis were created from the digital recordings by playing the digital recording while holding up a small tape recorder to the speaker.

5. OVERVIEW OF TEST RESULTS

This section includes an overview of the test results. Section 5.1 provides a summary of the overall assessment of the Gateway Subsystem. Sections 5.2 and 5.3 provide a narrative description of the functional tests and the operational tests, respectively. The applicability of the test environment to actual operations is discussed in Section 5.4. The section concludes with some recommendations for additional improvements to the capability.

5.1. Overall Assessment of the Gateway Subsystem

Overall, the Gateway Subsystem met the functional requirement of allowing officers from one agency using their own agency's radio system to directly communicate with officers of another agency using a radio system operating on a different frequency band. Initial results were acceptable, and were improved by conducting several sessions of fine-tuning parameter settings of the ACU-1000 (and in some cases, the radios themselves). The functional and operational test results include the following:

1) The Gateway Subsystem, based on the ACU-1000 switch, provides effective (i.e., sufficiently high quality and sufficiently low delays) radio-to-radio communication with radio systems operating in different frequency bands. The switch supports one-to-one connections or radio "conference calls." With respect to the functional requirements of Communication, Control, Interoperability, and Voice Quality (identified in Section 3.1):
    a) Communications—Communications were accomplished between the ACU-1000 operator, dispatch centers of the participating agencies, and field officers of the participating agencies.
    b) Control—The ACU-1000 operator was able to establish the required connections quickly and accurately.
    c) Interoperability—Field officers from different agencies could communicate, even when their radio systems operated in different frequency bands.
    d) Voice Quality—Once parameters were adjusted, most transmissions were clearly understandable, with no discernable degradation introduced by the ACU-1000. In some cases, transmission of lower quality were retransmitted at comparable quality; i.e., the ACU-1000 neither improved nor degraded the quality of the audio. The ACU-1000 itself introduced no discernable delays in transmissions; however, to avoid introducing a ping pong effect in interfacing with repeaters of the participating agencies, it was necessary to set some parameters to a level that resulted in a delay in transmissions. While noticeable, these delays did not impact operations.[1]
2) Operator control of the ACU-1000 itself is easy, and the graphical user interface is intuitive. Connections can be made or changed at the click of a mouse.

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[1] In the case of APD, USPP, and MPD, the initial results were adequate, and were improved by conducting several sessions of manipulating parameter settings of the ACU-1000 (and in some cases, the radios themselves). Interface with the Transit Police radio system was more problematic. Transmission problems persisted despite a number of attempts to address transmission quality issues. Two characteristics of the Transit Police radio system contributed to the challenge. First, since Transit Police has only one operational channel, testing was conducted on a non-interfering basis, and on multiple occasions, testing was suspended due to operational activities. Second, there are some audio quality problems inherent in the Transit Police system. (The Transit Police's long-term solution is a new WMATA radio system scheduled for completion in July 2002.)

In addition to these specific conclusions based on the capabilities identified in Section 3.1, we also make the following general observations about the deployment and use of the ACU-1000 to achieve interoperability.

3) There are a number of programmable parameters on the ACU-1000 that can be changed through the user interface. Default parameters are acceptable but not necessarily optimal. Testing and fine-tuning is required to determine the optimal setting of the parameters.

4) By far the most challenging technical aspect of the deployment of the ACU-1000 was in interfacing with the repeater systems of the participating agencies. In systems in which a radio interfaced to the ACU-1000 is transmitting to a receiver site through a repeater, due to the length of the squelch tail, a repeater could stay up long enough to bring the radio connected to the ACU-1000 back up before the repeater goes down. Then because the radio is back up, the repeater could come back up, bringing the radio back up; and so on. This effect is referred to as the "ping pong" effect. The deployed solution uses Voice Modulated Recognition (VMR), which is appropriate for use with radios that operate with open squelch. However, we also note that the appropriate Carrier operated relay (COR) type for a given installation is a tradeoff of radio operations, repeater squelch type, and acceptable delay within the system. A more detailed discussion of the ping pong effect and the deployed solution is included in Appendix A.

5) Interagency communications require additional training. Officers should train with the capability prior to operational use; this is particularly critical if officers have not previously worked directly with officers of other participating agencies. During the functional test it became clear that officers needed to use plain English rather than "10 codes," since a "10-99" for one department is an acknowledgement from a 1-officer vehicle, but is the code for a felony traffic stop for another department.

5.2. Impact of Test Environment

In terms of the functions of the system, the test environment was basically the same as the operating environment. The tests were designed to be performed with as little disruption to ongoing law enforcement agency operations as possible. Under operational conditions, there will be a number of differences in terms of the level of training of the officers using the system, the amount of voice traffic on the channels being linked, and so on. To address the impact of these operational considerations, a series of operational tests of increasing complexity were performed to address the operational aspects of using the Gateway Subsystem.

5.3. Recommended Improvements

Based on the test results, we recommend several improvements to the Gateway Subsystem. These recommendations fall into three categories:

- Recommended modifications to the ACU-1000 which have been forwarded to the ACU-1000 manufacturer (JPS Communications).

  There were some aspects of the installation of the Gateway Subsystem that were not completed at the time of the tests documented in this report. These capabilities will be needed for full operation, but the Gateway Subsystem can be used without them. These capabilities include:

1. An interface to the PSTN system;
2. Individual speakers for each radio; and
3. An interface to the Dispatch Supervisor's console in the dispatch center.

The above items will be completed and should be tested when renovation of the APD Dispatch Center is completed. In addition, DTMF control of the ACU-1000 from the field was not tested in this test, since field control has not yet been incorporated into the operational requirements of the Gateway Subsystem.

- Expansion of the number of agencies included in the Communications Interoperability Capability.

  During execution of the test, the test operator was careful to ensure that upon completion of a test and prior to disconnecting a linkage between radios, the radios were either turned off or turned to an inactive channel. This step is necessary because the ACU-1000 broadcasts an audio confirmation of all connection and disconnection actions on all radio channels that are connected. While useful in some cases, the message is broadcast to all radio networks that are being connected or disconnected (unless the radio connected to the ACU-1000 is turned off or moved off-channel). The recommended improvement, which was forwarded to the equipment manufacturer, is to provide a means to disable the audio confirmation of connections and disconnections within the ACU-1000.

- Completion of the Gateway Subsystem installation to allow testing of functions that were not able to be tested during this test, and which are not critical to beginning the operational evaluation, but which are part of the final Gateway Subsystem configuration.

  The agencies that participated in the tests described in this section represent a subset of the agencies with whom Alexandria Police Department interfaces on a regular basis. The existing infrastructure can support additional agency participation.

6. TESTS

There are five tests documented in this section. The Functional Test was conducted to exercise the Gateway Subsystem and ensure that the subsystem worked as anticipated. This test was followed by a series of Operational Tests. These Operational Tests further exercised the Gateway Subsystem within the context of operational scenarios that represented realistic application of the interoperability capability provided by the Gateway Subsystem. Operational Test #1 simulated handoff of surveillance of a vehicle as it traveled from one jurisdiction to another. Operational Test #2 simulated traffic control involving multiple agencies. Based on the results of these two tests, several changes were made to the Gateway Subsystem to improve performance. The two operational tests were rerun as Operational Test #3 and Operational Test #4. The results of each of these tests are documented in the subsections that follow.

6.1. Functional Test

6.1.1. Test Conditions

Date**:**	Friday July 21, 2000 @ 0500
Scenario**:**	Radio checks only.
Purpose**:**	To establish that the Gateway Subsystem functions as intended.
Lead Agency**:**	Alexandria Police Department (lead agency)
Participating Agencies:	United States Park Police, Metro Transit, and Metropolitan Police Department (DC)
Resources::	APD: Lt. Roman Kaluta to monitor ACU-1000 and to establish cross-band links. Dispatch and field officer to conduct radio checks upon request.
	USPP: Dispatch and field officer to conduct radio checks upon request.
	MPDC: Dispatch and field officer to conduct radio checks upon request.
	Transit: Dispatch and field officer to conduct radio checks upon request.
Channels:	APD: Zebra (non-operational channel), OPS-2
	USPP Tact Channel 3
	MPS Citywide 1
	Transit Main Operational Channel

6.1.2. Test Description

The functional tests are organized into test sets that progressively test the capabilities of the subsystem. The tests were originally planned as follows:

Set A Tests 1 – 4: Receive only – no links

Set B	Tests 5 – 8:	Receive only, audio link to PSTN-1, no transmissions
Set C	Tests 9 – 11:	Transmission tests to APD's Zebra (currently non-operational) channel
Set D	Tests 12 – 15:	Scripted transmission tests to communications centers, no links
Set E	Tests 16 – 19:	Scripted transmission tests direct to field units, no links
Set F	Tests 20 - 21:	Tests links and unit-to-unit transmissions
Set G	Test 22:	Test link within same band (USPP – Metro Transit)
Set H	Test 23:	Link multiple bands with units side by side

6.1.3. Summary of Results

The first eight tests involved monitoring transmissions between dispatchers and field units. These were "listen only" tests and there were no transmissions from the Gateway Subsystem. The functional tests were scheduled during non-peak hours to minimize disruptions to normal operations. Some of the departments had very little, if any, radio traffic occurring at five o'clock in the morning. In some cases radio traffic was initiated by calling the dispatcher via landline and asking them to conduct a radio test with a field unit.

In most cases the signals of both the dispatch centers and the field units could be monitored loud and clear at the ACU-1000. One exception was on MPD's Sixth District (6D) channel, which had some static (the Gateway Subsystem had not been configured to work with that particular channel). The Gateway Subsystem antenna is a directional antenna aimed at MPD's repeater for the City Wide 1 channel. However, when attempting to monitor MPD on its City Wide 1 channel (Test 2), we found that the channel was not in use during the midnight tour. We scanned their channels and found radio traffic on their Sixth District (6D) channel (whose repeater is at a location different than the City Wide 1 repeater). That field unit's transmission had some static.

Separate tests were planned to first check reception by each radio prior to switching any audio through the ACU-1000 (tests 1 through 4), then executing the same "listen-only" test but switching the audio from the receiving radio to the PSTN-1 (telephone) interface (tests 5 through 8). These tests were combined; rather than checking each radio without switching it through the ACU-1000, the radios were checked by switching them through the ACU-1000 and transmitting on the handset interface to the ACU-1000. This interface was used rather than the telephone interface (thus no data was collected as specified for tests 5 through 8, which required the PSTN interface).

In the next series of tests (9 through 11), transmissions of the various departments were to be monitored and re-broadcast over a non-operational APD channel. No transmissions were made from the Gateway Subsystem. Of the three agencies to be monitored during this series of tests, only MPD had radio traffic at this hour of the morning. The link proved successful and MPD's Second District was re-broadcast over APD's Zebra channel and monitored on an APD handheld radio. When the link was established for the USPP, no radio communications were taking place. However, there was a carrier being transmitted periodically, which appears to have been someone keying a microphone. Rather than wait an indefinite period for traffic to occur on USPP and Metro Transit Police bands, testing moved to the next series of tests, which called for transmissions from the ACU-1000 to generate radio traffic.

The next series of tests (12 through 15) called for the Gateway Subsystem to be used to contact each of the communications centers. In every case both the transmission and reception signals were good.

In testing the ACU-1000's ability to communicate with field units (tests 15 through 19) of each of the jurisdictions, each respective communications center was first called on their operational frequencies via the ACU-1000. The dispatcher was then asked to select an in-service field unit to switch over to a tactical channel. Field units were randomly selected by the dispatchers of the respective agencies. With the field units standing by on their tact channels, a radio test was conducted from the Gateway Subsystem to each of them. In one case (test 17), the field unit reported hearing a humming noise in the background, possibly caused by the fact that the handset of the ACU-1000 was close to the top mounted fan in the rack housing the ACU-1000. All other field units reported loud and clear signals.

The final series of tests called for links to be established between field units of the various departments operating in different frequency bands (VHF, UHF, and 800 MHz) and located in different areas of the Washington metropolitan region. A ping-pong effect (see Appendix A) was observed during execution of test 22, involving transmission between USPP and Metro transit field units. One radio was still keyed at the conclusion of the transmission, which caused the other system to key up while the first was keying down; this sequence repeated for a series of about 5 oscillations. We changed the "squelch type" setting from VOX to VMR, which eliminated this problem. Test 22 was re-conducted successfully.

Test 23, which called for all the field units to report to a single location was not conducted due to reaching pre-agreed time limit for the test (to avoid impacting operations).

An annotated script and detailed results of the Functional Test is provided as Appendix C of this Test Document.

6.1.4. Resulting Modifications to the Settings of the Gateway Subsystem

After the initial functional test of July 21, 2000, the Transmit and Receive level settings in the DSP cards of the ACU-1000 were adjusted based on a low volume from the HSP-1 handset and to improve overall audio quality. These settings were made by monitoring the channel and/or by transmissions to a single agency.

The Transmit level for the 800 MHz radio was adjusted to level 9 (12 dBm gain). However, the 800 MHz Astro digital trunked radio began failing by intermittently going into a self-check mode and then powering down. The Transmit level was reset to a 0 dBm gain (default setting of 6), which eliminated the problem, as the radio no longer went into self-check mode. This cause and effect condition was verified by cycling the setting back to level 9, which again caused the radio to go into self-check mode. JPS confirmed that certain radios could be overpowered causing this problem.

The Transmit level was set back to 6, which eliminated the overdrive problem, and resulted in better voice quality. The Receive levels were adjusted accordingly.

The other significant change involved the Squelch Type. VOX triggers on any audio (including noise) present on the radio channel, while VMR triggers only on voice audio. Although the VMR worked in the functional test, it also required a high COR Inhibit Time to avoid the ping pong effect. The next parameter configuration to be tried was to restore the

Squelch Type, which had been set to VMR during the Functional Test, to VOX, and to reset the COR Inhibit Time to the default parameter, 1. Finally, the DTMF Mute Timer was turned off.

The results of the modifications to the DSP parameters in the ACU-1000 as a result of the above activities, and therefore that were in place for Operational Test #1 are listed in Table 6. Settings that were changed from those used in the Functional Test are highlighted in blue.

Table 6: DSP Settings for Operational Test #1

DSP Slot	1	2	4	5	6	7
Radio Type	800 MHz Digital Trunked	800 MHz Digital Trunked	450 MHz MCS2000	450 MHz MCS2000	150 MHz MCS2000	150 MHz MCS2000
DSP Module Name	APD	800	UHF	MPD	WMATA	USPP
TX Level	6	6	6	6	6	6
RX Level	3	3	3	3	3	3
Squelch Type	VOX	VOX	VOX	VOX	VOX	VOX
VOX/VMR threshold	1	1	1	1	1	1
DTMF Mute Timer	0	0	0	0	0	0
Security Level	0	0	0	0	0	0
VOX/VMR Hangtime	1	1	1	1	1	1
Audio Equalizer	0	0	0	0	0	0
Positive/Negative COR	Negative	Negative	Negative	Negative	Negative	Negative
COR Sampling Enabled/Disabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Audio Delay Time	1	1	1	1	1	1
Half/Full Duplex	Half	Half	Half	Half	Half	Half
COR Sampling Initial Delay Time	4	4	4	4	4	4
COR Sampling Interval	4	4	4	4	4	4
Squelch On/Off	On	On	On	On	On	On
COR Sampling Width	2	2	2	2	2	2
Keying T	0	0	0	0	0	0
PTT/COR Priority	PTT	PTT	PTT	PTT	PTT	PTT
Peaker Value	0	0	0	0	0	0
COR Inhibit Time	1	1	1	1	1	1
Keying	1	1	1	1	1	1
DTMF Command Disabled/Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Out Control User/Local	Local	Local	Local	Local	Local	Local
Radio Type	0	0	0	0	0	0

6.2. Operational Test #1

6.2.1. Test Conditions

Date**:**	Monday August 28, 2000 @ 0500
Scenario**:**	Vehicle "follow-the-leader" exercise.
Purpose**:**	To simulate a vehicle escort, surveillance and/or pursuit under normal and legal driving conditions. To monitor how mobile units communicate/coordinate with each other while utilizing a cross-band radio link during a mobile surveillance. Utilize a progressive cross-band radio link, first between Alexandria and USPP, then adding MPDC (these three agencies on Tact Frequencies) and then adding Transit Police when the escort ends at a Metro Subway Station in Washington, D.C.
Lead Agency**:**	Alexandria Police Department
Participating Agencies:	United States Park Police, Metro Transit and Metropolitan Police Department (DC)
Resources::	APD: Lead Vehicle, unmarked operated by Lieutenant Kaluta, Marked Cruiser, first following vehicle. Dispatcher to monitor the radio traffic during the scenario. Bob Moseley to monitor ACU-1000 and connect cross-band links when requested. USPP: Marked Cruiser, to intercept APD Marked Vehicle and Lead Vehicle somewhere on the George Washington Parkway north of Alexandria. MPDC: Marked Cruiser, to intercept APD Marked Vehicle and Lead Vehicle and USPP Marked Vehicle somewhere on 14th Street near the Washington Monument. Transit: Marked Cruiser, to intercept the lead and following vehicles in the area of a Metro Subway Station near the mall.
Channels:	APD: OPS-2 USPP Tact Channel 3 MPD Command Channel Transit Main Operational Channel

6.2.2. Test Description

An Alexandria marked unit will be following another vehicle. For the purposes of this scenario, the lead vehicle can represent a fleeing vehicle, a vehicle containing a wanted suspect, and so on. However, during this exercise all vehicles will be operated normally and legally without use of any emergency equipment.

The lead vehicle, followed by the APD cruiser, will proceed out of the Alexandria City limits north on George Washington Parkway. It will be the responsibility of the APD officer to inform the APD Dispatcher of the lead vehicle description and request a cross-band radio link with USPP. The APD officer will coordinate their location and direction of travel by radio with the USPP back-up unit.

Once intercepted by USPP, both the Alexandria and USPP cruiser will continue to follow the lead vehicle. The USPP cruiser will take over the responsibility to coordinate radio traffic, noting location, direction when and/or if asked by the APD Dispatcher.

When it becomes apparent to the USPP cruiser that the lead vehicle will be entering Washington, D.C., the USPP cruiser will request a cross-band link with MPDC and coordinate with their cruiser who will intercept the escort somewhere in the area of 14th Street.

Once intercepted, the MPDC cruiser will then take over the radio traffic noting location, direction of travel, and so on. When the lead vehicle nears a Metro Subway Station, the MPDC cruiser will request a cross-band link with Metro Transit Police.

Once the cross-band link is established the MPDC cruiser will inform the Transit back-up unit of their location and coordinate a stop of the lead vehicle with the Transit officer at the Subway Station. Once the escort is stopped, Lieutenant Kaluta will notify Mr. Moseley and all cross-band radio links will be disconnected.

Throughout this mock scenario all participants will utilize “Plain English” radio communications. No “TEN” or other codes are to be used.

The units involved will identify themselves as follows:

- Alexandria PD: “Alexandria Unit/Cruiser Number”
- USPP: “US Park Unit/Cruiser Number”
- MPDC: “DC Unit/Cruiser Number”
- Transit: “Transit Cruiser 100”

Each agency representative will brief the officers involved in the scenario and have them at a location ready to participate at 0500 hours. The officers should be standing by on their respective radio frequencies.

As to not burden operational units with this first mock scenario, agency representatives are encouraged to participate as the “back-up units.” This will provide greater feedback as to radio transmission quality, and so on.

6.2.3. Summary of Results

On August 28, 2000 at 0500 hours the first multiple agency joint operational test of the Gateway Subsystem was conducted. During the test Bob Moseley operated the ACU-1000. APD Lt. Roman Kaluta drove the civilian target vehicle and coordinated field operations.

The unit initially following the target vehicle was APD unit 131, who was operating on APD OPS 2 channel. Unit 131 began with the initial transmission, “I have a vehicle not stopping for me… prepared to copy vehicle information?” After giving the information on the target vehicle, unit 131 indicated that they were "east bound Prince (street) crossing South Patrick". Communications were loud and clear (at this point no cross band switching was being used).

APD unit 131 followed the vehicle onto northbound Washington Street, heading toward National Airport and the District of Columbia. As unit 131 left the city, he requested that a cross band communications link be established with the U.S. Park Police. At that time the link was established between APD OPS 2 and the U.S. Park Police Tact Channel 3.

APD 131 called USPP via his radio and USPP car 50 answered. APD 131 voiced the description of the vehicle. Communications from USPP car 50 were understandable but there was considerable static. USPP voiced that he was "right behind the vehicle." After each transmission from USPP there was a brief period of noise.

As they entered the District of Columbia, USPP car 50 requested that the Metropolitan Police Department be added to the link. MPD's Command channel was then linked in with APD and the USPP. MPD unit 1071 was standing by as they entered the District. MPD unit 1071's transmission was loud and clear. At the ends of the transmissions there was static and the clicking of the ping-pong effect was audible but the transmission was understandable.

When the units approached 14th and Independence, they requested a link with the Metro Transit Police. Metro Transit cruiser 100 had difficulty copying the transmissions. The ping-pong effect worsened. Metro Transit 100 did communicate and give location but continued to have difficulty copying.

At this point Operational Test 1 was concluded and the units were returned to service.

6.2.4. Resulting Modifications to the Settings of the Gateway Subsystem

The major issue identified during this operational test was the ping pong effect. In an attempt to address this problem, a number of changes were made to the parameter settings.

The first modification was a change to the Squelch Type from VOX to VMR, but with an increase in VMR hangtime from 375 msec to 775 msec for all the radios. Testing with these parameters improved performance but did not eliminate the ping pong effect. The hangtime for the APD digital trunked radio was then adjusted up to 1.575 seconds. The COR Inhibit after PTT parameter for all radios was raised from 100 msec back to 1 second. Audio inhibit times were also adjusted.

Voice Modulation Recognition (VMR) helps to reduce the ping-pong by only sending a COR signal when the processor recognizes the characteristics of human voice. Increasing the COR inhibit after PTT causes the ACU-1000 to ignore the Squelch Tail for a period of time, in this case 1 second.

Finally, the Peaker Value for the MPD radio was raised to reduce noise characteristic of the MPD system. The results of the modifications to the DSP parameters in the ACU-1000 that were in place for Operational Test #2 are listed in Table 7.

Table 7: DSP Settings for Operational Test #2

DSP Slot	1	2	4	5	6	7
Radio Type	800 MHz Digital Trunked	800 MHz Digital Trunked	450 MHz MCS2000	450 MHz MCS2000	150 MHz MCS2000	150 MHz MCS2000
DSP Module Name	APD	800	UHF	MPD	WMATA	USPP
TX Level	7	7	6	6	5	3
RX Level	5	3	5	5	6	6
Squelch Type	VMR	VMR	VMR	VMR	VMR	VMR
VOX/VMR threshold	3	1	1	1	1	1
DTMF Mute Timer	0	0	0	0	0	0
Security Level	0	0	0	0	0	0
VOX/VMR Hangtime	7	3	3	3	4	4
Audio Equalizer	0	0	0	0	0	0
Positive/Negative COR	Negative	Negative	Negative	Negative	Negative	Negative
COR Sampling Enabled/Disabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Audio Delay Time	1	3	0	1	0	0
Half/Full Duplex	Half	Half	Half	Half	Half	Half
COR Sampling Initial Delay Time	4	4	4	4	4	4
COR Sampling Interval	4	4	4	4	4	4
Squelch On/Off	On	On	On	On	On	On
COR Sampling Width	2	2	2	2	2	2
Keying T	0	0	0	0	0	0
PTT/COR Priority	PTT	PTT	PTT	PTT	PTT	PTT
Peaker Value	0	0	0	1	0	0
COR Inhibit Time	5	5	5	5	5	5
Keying	1	1	1	1	1	1
DTMF Command Disabled/Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Out Control User/Local	Local	Local	Local	Local	Local	Local
Radio Type	1	0	0	0	0	0

6.3. Operational Test #2

6.3.1. Test Conditions

Date**:**	Monday September 11, 2000 @ 0500
Scenario**:**	Multiple vehicular accident on the George Washington Parkway just north of the Washington Sailing Marina.
Purpose**:**	To simulate the handling of a multiple vehicular accident on the George Washington Parkway by the United States Park Police that is blocking traffic in both the north and south bound lanes using the assistance of the Alexandria, Metropolitan and Transit Police Departments for traffic control. To monitor how mobile units communicate/coordinate with each other while utilizing a cross-band radio link. To utilize a cross-band radio link between the United State Park Police and the Alexandria, Metropolitan and Metro Transit Police Departments.
Lead Agency**:**	United States Park Police
Participating Agencies:	Alexandria Police Department, Metro Transit and Metropolitan Police Department (DC)
Resources::	USPP: Marked Cruiser, initial responders to the accident scene (simulated) on the George Washington (GW) Parkway just north of the sailing marina. Alexandria: Two police vehicles to simulate the diversion of northbound traffic on the GW Parkway at Slaters Lane. One vehicle will be operated by Lieutenant Kaluta and the other by an Alexandria patrol officer. Bob Moseley will monitor the ACU-1000 and connect cross-band links when requested. At the start of the scenario, Mr. Moseley will be monitoring USPP Channel 3. MPDC: Marked Cruiser operated by Sergeant Al Sines to simulate the diversion of southbound traffic on the GW Parkway at the National Airport exit. Transit: An officer with a mobile radio at the Reagan National Airport Metro Station to assist with traffic control at the airport.
Channels:	APD: OPS-2 USPP Tact Channel 3 MPD Command Channel Transit Main Operational Channel

6.3.2. Test Description

For this scenario, Mr. Moseley will be located at the ACU-1000 at APD at 0500 hours. The USPP, Alexandria, MPDC, and Transit officers will meet at the Washington Sailing Marina at 0500 hours. The unit deployments described below are depicted on the map in Figure 2.

A USPP marked unit(s) will respond to a multiple vehicular accident northbound on the George Washington Parkway just north of the Washington Sailing Marina. After finding north and south bound traffic blocked, the USPP officer will request assistance from the Alexandria and Metropolitan Police Departments for traffic control.

A cross-band link will first be established with Alexandria who will simulate the blocking of northbound traffic at Slaters Lane, diverting the traffic to US Route 1. A cross-band link will then be established with the MPDC unit who will simulate the blocking of southbound traffic at the exit to National Airport, diverting the traffic to the Airport and/or back to northbound GW Parkway.

Once the traffic control has been established, the scenario simulates the diverted southbound traffic attempting to reenter the parkway by looping around at National Airport. At this time USPP will request a cross-band link with Transit and request they assist in the blocking of the return ramp from the airport to southbound GW Parkway. This will be a limited cross-band link at the end of the scenario to ensure that Transit's radio system is not tied up too long.

Throughout this mock scenario all participants will utilize "Plain English" radio communications. No "TEN" or other codes are to be used.

The units involved will identify themselves as follows:

- Alexandria: "Alexandria Unit 17" (Lt. Kaluta) and "Alexandria/Cruiser Number"
- USPP: "US Park Unit/Cruiser Number"
- MPDC: "DC Unit/Cruiser Number (Sgt. Sines)"
- Transit: "Transit Cruiser Number"

Any officers involved in this operation should be briefed that this is a mock scenario. All officers should wait momentarily at the beginning of (when keying the microphone) and end of each transmission (once the carrier signal has dropped) before beginning their transmissions.

In this scenario, only the accident, the blocking of traffic, and the diversion of traffic north and south of the scene is simulated. Emergency equipment will not be used, and traffic will not be stopped, blocked or diverted.

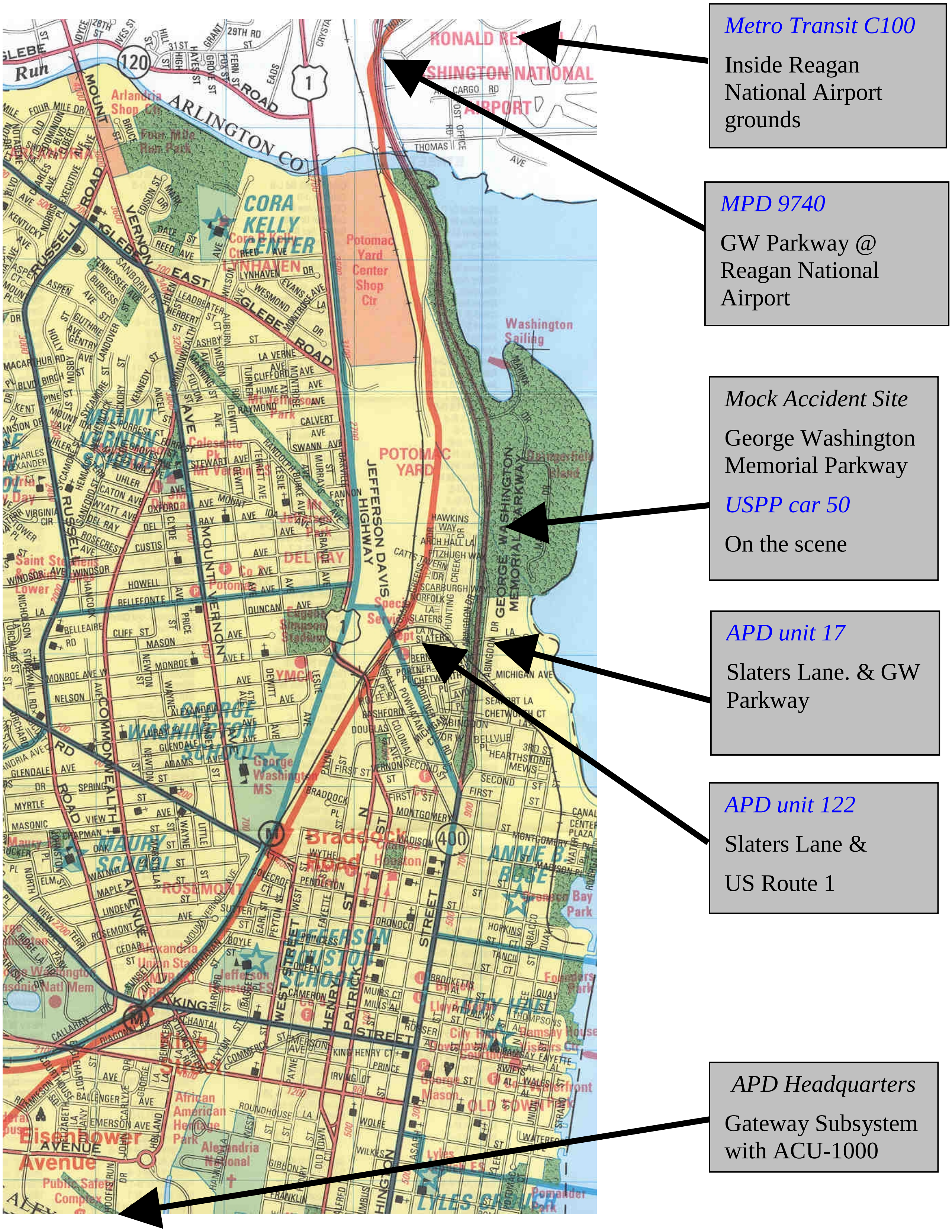

Figure 2: Unit Locations for Operational Test #2

6.3.3. Summary of Results

Operational Test #2 was conducted on September 11, 2000, at 0500 hours. During the test, Bob Moseley operated the ACU-1000. Alexandria Police Lt. Roman Kaluta coordinated field operations. The units involved in the test were APD unit 17, APD unit 122, MPD cruiser 100, USPP car 50 and Metro Transit cruiser 100.

USPP car 50 initiated the communications by calling the Alexandria Dispatch via an established link through the ACU-1000 and requesting assistance with traffic control around the simulated accident site. APD Dispatch assigned unit 17 and unit 122.

With USPP and APD linked together the transmission quality was very understandable but there was still considerable noise. There was, however, a significant improvement over the quality and noise level of Operational Test #1.

When MPD was linked in, MPD cruiser 9740 responded. Voice quality remained understandable between most units but there was significant noise and the ping-pong effect was observed on an intermittent basis. USPP was removed from the link, leaving only APD and MPD, and there was moderate improvement in the quality. USPP was reinstated in the loop but were removed just before the link with Metro Transit was established.

APD 17 conducted car to car transmissions to Metro Transit cruiser 100. Directions for traffic control were voiced. Transmissions were understandable by all units. At this point three agencies were connected (MPD, APD and Metro Transit). USPP was reinstated in the link but did not answer and was again removed from the loop.

At 0544 hours the test was concluded and links were removed.

6.3.4. Resulting Modifications to the Settings of the Gateway Subsystem

Although the audio quality was improved in this test, some additional adjustments were required before proceeding with additional tests,[2] beginning with disabling COR Sampling. COR Sampling puts holes in the audio by intentionally interrupting the signal on user-defined intervals. The purpose of this feature is to allow another radio to gain access in the middle of a long transmission. The default setting is “Enabled”, but since the anticipated radio traffic in this application involves typically short transmissions, there is no requirement to be able to break into a transmission, and therefore no need for the COR sampling. With COR Sampling turned off the audio quality was much improved. There were less gaps in the audio and fewer dropouts.

In observing the signal lights of the DSP-1 modules, it appeared that the Rx levels were still too high, as the signal lights were on most of the time. The Receive level was reduced to the point that the signal lights flashed only momentarily during voice peaks.

In observing the COR signal lights of the DSP-1 module, the MPD’s DSP module COR was about 2 seconds after a transmission finished. Initially, COR inhibit after PTT was raised to 3 seconds to mask this event. Since a 3 second delay is too long for police communications, alternative approaches were considered. Since MPD’s squelch tails are less than 500 msec, their squelch tails were not contributing to the problem. However, MCS-2000 radios connected to the ACU-1000 switch have a HUB, or “Hang Up Button,” setting that overrides the “Tone Squelch”

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[2] These modifications were made with the support of an engineer from JPS, the manufacturer of the ACU-1000.

of the radio when the HUB is enabled. This setting inhibits termination of the squelch tail. The HUB settings in the radios themselves were reset to “Disabled.” Then the ACU-1000 COR inhibit after PTT was reduced to 400 msec and the VMR Hangtime was set to 975 msec. Audio delay and VOX/VMR threshold parameters were adjusted accordingly. Audio throughput in the ACU-1000 was much improved and only minimal ping-pong was observed.

Adjustments were also made to improve the quality of the audio. Audio Equalizer and Peaker Value parameter settings on each channel were adjusted until the best results were obtained.

The results of the modifications to the DSP parameters in the ACU-1000 as a result of the above activities, and therefore that were in place for Operational Test #3 are listed in Table 8. Settings that were changed from those used in Operational Test #2 are highlighted in blue.

Table 8: DSP Settings for Operational Test #3

DSP Slot	**1**	**2**	**4**	**5**	**6**	**7**
Radio Type	800 MHz Digital Trunked	800 MHz Digital Trunked	450 MHz MCS2000	450 MHz MCS2000	150 MHz MCS2000	150 MHz MCS2000
DSP Module Name	APD	800	UHF	MPD	WMATA	USPP
TX Level	3	3	6	4	4	4
RX Level	5	5	5	4	5	6
Squelch Type	VMR	VMR	VMR	VMR	VMR	VMR
VOX/VMR threshold	2	2	2	2	2	2
DTMF Mute Timer	0	0	0	0	0	0
Security Level	0	0	0	0	0	0
VOX/VMR Hangtime	4	4	4	4	5	6
Audio Equalizer	4	4	4	4	8	4
Positive/Negative COR	Negative	Negative	Negative	Negative	Negative	Negative
COR Sampling Enabled/Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Audio Delay Time	7	7	7	7	7	7
Half/Full Duplex	Half	Half	Half	Half	Half	Half
COR Sampling Initial Delay Time	4	4	4	4	4	4
COR Sampling Interval	4	4	4	4	4	4
Squelch On/Off	On	On	On	On	On	On
COR Sampling Width	2	2	2	2	2	2
Keying T	0	0	0	0	0	0
PTT/COR Priority	PTT	PTT	PTT	PTT	PTT	PTT
Peaker Value	2	2	1	1	7	2
COR Inhibit Time	3	3	3	3	3	2
Keying	1	1	1	1	1	1
DTMF Command Disabled/Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Out Control User/Local	Local	Local	Local	Local	Local	Local
Radio Type	1	0	0	0	0	0

6.4. Operational Test #3

The scenario seen in Operational Test #1 was also used for Operational Test #3. The scenario was repeated because of the number of parameter changes that were made to the ACU-1000 to improve audio quality and eliminate ping-pong effects. By repeating the test the impact of these setting changes can be observed without having to account for differences inherent in a different scenario.

6.4.1. Test Conditions

Date**:**	Monday October 2, 2000 @ 0500
Scenario**:**	Vehicle "follow-the-leader" exercise (Repeat of Operational Test #1).
Purpose**:**	To simulate a vehicle escort, surveillance and/or pursuit under normal and legal driving conditions. To monitor how mobile units communicate/coordinate with each other while utilizing a cross-band radio link during a mobile surveillance. Utilize a progressive cross-band radio link, first between Alexandria Police Department and USPP, then adding MPDC (these three agencies on Tact Frequencies) and then adding Transit Police when the escort ends at a Metro Subway Station in Washington, D.C.
Lead Agency**:**	Alexandria Police Department
Participating Agencies:	United States Park Police, Metro Transit and Metropolitan Police Department (DC)
Resources:	APD: Lead Vehicle, unmarked operated by Lieutenant Kaluta, Marked Cruiser, first following vehicle. Dispatcher to monitor the radio traffic during the scenario. Bob Moseley to monitor ACU-1000 and connect cross-band links when requested. USPP: Marked Cruiser, to intercept APD Marked Vehicle and Lead Vehicle on the George Washington Parkway at the sailing marina. MPDC: Marked Cruiser, to intercept APD Marked Vehicle and Lead Vehicle and USPP Marked Vehicle on 14^{th} Street just over the 14^{th} Street Bridge. Transit: Marked Cruiser, to intercept the lead and following vehicles in the area of a Smithsonian Institute on Jefferson Drive S.W
Channels:	APD: OPS-2 USPP Tact Channel 3 MPD Command Channel Transit Main Operational Channel

6.4.2. Test Description

An Alexandria marked unit will be following another vehicle. For the purposes of this scenario, the lead vehicle can represent a fleeing vehicle, a vehicle containing a wanted suspect, and so on. However, during this exercise all vehicles will be operated normally and legally without use of any emergency equipment.

The lead vehicle followed by the APD cruiser will proceed out of the Alexandria City limits north on the George Washington Parkway. It will be the responsibility of the APD officer inform the APD Dispatcher of the lead vehicle description and request a cross-band radio link with USPP. The APD officer will coordinate their location and direction of travel by radio with the USPP back-up unit.

Once intercepted by USPP, both the Alexandria and USPP cruiser will continue to follow the lead vehicle. The USPP cruiser will take over the responsibility to coordinate radio traffic, noting location, direction when and/or if asked by the APD Dispatcher.

When it becomes apparent to the USPP cruiser that the lead vehicle will be entering Washington, D.C., the USPP cruiser will request a cross-band link with MPDC and coordinate with their cruiser who will intercept the escort somewhere in the area of 14th Street.

Once intercepted the MPDC cruiser will then take over the radio traffic noting location, direction of travel, and so on. When the lead vehicle nears a Metro Subway Station, the MPDC cruiser will request a cross-band link with Metro Transit Police.

Once the cross-band link is established the MPDC cruiser will inform the Transit back-up unit of their location and coordinate a stop of the lead vehicle with the Transit officer at the Subway Station. Once the escort is stopped, Lieutenant Kaluta will notify Mr. Moseley and all cross-band radio links will be disconnected.

Throughout this mock scenario all participants will utilize “Plain English” radio communications. No “TEN” or other codes are to be used.

Participants are encouraged to generate sustained voice transmissions between each other, such as the description of the vehicle being followed, direction of travel and confirmation of location. This is necessary to monitor the voice quality of the transmissions and to ensure the transmissions are complete and not being cut off/dropped.

The units involved will identify themselves as follows:

- Alexandria: “Alexandria Unit 17 (Lt. Kaluta)”
- “Alexandria Unit ______ (Beat Officer)”
- USPP: “US Park Unit/Cruiser ________”
- MPDC: “DC Unit/Cruiser 9740 (Sgt. Sines)”
- Transit: “Transit Cruiser _________”

Each agency representative will brief the officers involved in the scenario and have them at a location ready to participate at 0500 hours. The officers should be standing by on their respective radio frequencies.

As to not burden operational units with this mock scenario, agency representatives are encouraged to participate as the "back-up units." This will provide greater feedback as to radio transmission quality, and so on.

6.4.3. Summary of Results

On October 2, 2000 at 0500 hours the third multiple agency joint operational test of the Gateway Subsystem was conducted. During the test Bob Moseley operated the ACU-1000. Alexandria Police Lt. Roman Kaluta (APD unit 17) coordinated the field operations. The field units taking part in this test were APD unit 17, APD unit 114, USPP car 211, DC cruiser 9740 and Metro Transit unit 100.

The scenario began with APD unit 114 calling in a staged pursuit "south bound on Pitt from Montgomery." The description of the pursued vehicle was called in. The pursued vehicle (APD unit 17) and APD unit 121 then turned northbound onto Washington Street. APD Unit 121 then asked for a link to US Park Police. The link was established and APD Unit 121 called for the US Park Police to assist. USPP car 211 answered and a description of the car was voiced from the APD Unit to the USPP unit.

At this time only the Alexandria PD and the US Park Police systems were linked. Unit to unit communications was clear and understandable. Communications such as "Alexandria 114 to Park Police – I've got you in sight. We're the vehicles coming up on you" was quickly answered with "I got you" from the USPP unit.

During the next transmission a moment later the USPP unit became difficult to understand. APD unit 17 had to ask him to repeat his transmission several times. The first syllable of his transmission was cut off and it seemed that he re-keyed the microphone between phrases causing more syllables to be lost. There was also a period of considerable noise.

USPP could be heard pretty clearly calling for a DC unit before he asked for that link to be brought up. As the ACU-1000 operator, Bob Moseley called the USPP car 211 to confirm that he wanted the link with MPD activated.

The link was established with MPD. Again, APD unit 17 intervened and voiced for the MPD unit to go direct to USPP car 211. MPD Cruiser 9740 called USPP car 211. MPD Cruiser 9740 was loud and clear but the USPP 211 suffered periods of considerable noise.

With these three channels linked units readily talked unit to unit. The units were now "north bound 14th Street at C Street approaching Independence Avenue." With MPD Cruiser 9740 giving intersection by intersection his messages where loud and clear. MPD Cruiser 9740 asked the USPP 211 to repeat his description. When USPP 211 repeated the description, there was humming in the background each time he transmitted. His speech was understandable but the noise level was high.

MPD Cruiser 9740 asked for a link to Metro Transit as they were headed for the subway station. MPD Cruiser 9740 called for a Metro Transit Unit. When none answered, the ACU-1000 operator attempted to raise a unit from Metro Transit. There was still no reply. There was no noise on the radio. It was learned that neither MPD Cruiser 9740 nor the AGILE transmissions were intelligible by the Metro Transit Unit. They therefore did not respond.

6.4.4. Resulting Modifications to the Settings of the Gateway Subsystem

The parameter settings were reviewed to determine if the ACU-1000 settings were responsible for the unintelligible transmissions. In an effort to compensate for a noisy signal on the Metro Transit radio system, the Audio Equalizer level had been set to 8 and the Peaker value (Noise reduction) had been set to 7. Each of these settings is extremely high compared to the other radios (see Table 8).

The Peaker value and the Audio equalizer values were reduced, resulting in successful radio checks with Metro Transit. The Metro Transit antenna direction was also adjusted to point to the new repeater site at Bailey's Crossroads. While these steps improved the quality of the audio, it was still not at the same level as achieved with the MPD and USPP systems. Part of the problem is that Metro Transit's system does not have a good signal to start with; transmissions through the Gateway Subsystem are no worse than the normal signal quality within the Metro Transit system.[3]

The results of the modifications to the DSP parameters in the ACU-1000 as a result of the above activities, and therefore that were in place for Operational Test #4 are listed in Table 9. Settings that were changed from those used in Operational Test #3 are highlighted in blue.

[3] Metro Transit is in the process of procuring an entire new radio system. A contract has been awarded and completion of the new system is scheduled for 2002.

Table 9: DSP Settings for Operational Test #4

DSP Slot	1	2	4	5	6	7
Radio Type	800 MHz Digital Trunked	800 MHz Digital Trunked	450 MHz MCS2000	450 MHz MCS2000	150 MHz MCS2000	150 MHz MCS2000
DSP Module Name	APD	800	UHF	MPD	WMATA	USPP
TX Level	3	3	6	4	4	4
RX Level	5	5	5	4	4	6
Squelch Type	VMR	VMR	VMR	VMR	VMR	VMR
VOX/VMR threshold	2	2	2	2	0	2
DTMF Mute Timer	0	0	0	0	0	0
Security Level	0	0	0	0	0	0
VOX/VMR Hangtime	4	4	4	4	6	6
Audio Equalizer	4	4	4	4	3	4
Positive/Negative COR	Negative	Negative	Negative	Negative	Negative	Negative
COR Sampling Enabled/Disabled	Disabled	Disabled	Disabled	Disabled	Disabled	Disabled
Audio Delay Time	7	7	7	7	7	7
Half/Full Duplex	Half	Half	Half	Half	Half	Half
COR Sampling Initial Delay Time	4	4	4	4	4	4
COR Sampling Interval	4	4	4	4	4	4
Squelch On/Off	On	On	On	On	On	On
COR Sampling Width	2	2	2	2	2	2
Keying T	0	0	0	0	0	0
PTT/COR Priority	PTT	PTT	PTT	PTT	PTT	PTT
Peaker Value	2	2	1	1	3	2
COR Inhibit Time	3	3	3	3	3	2
Keying	1	1	1	1	1	1
DTMF Command Disabled/Enabled	Enabled	Enabled	Enabled	Enabled	Enabled	Enabled
Out Control User/Local	Local	Local	Local	Local	Local	Local
Radio Type	0	0	0	0	0	0

6.5. Operational Test #4

6.5.1. Test Conditions

Date**:**	Friday October 20, 2000 @ 2200
Scenario**:**	Multiple vehicular accident on the George Washington Parkway just north of the Washington Sailing Marina. (Repeat of Operational Test #2)
Purpose**:**	To simulate the handling of a multiple vehicular accident on the George Washington Parkway by the United State Park Police that is blocking traffic in both the north and south bound lanes using the assistance of the Alexandria, Metropolitan and Transit Police Departments for traffic control. To monitor how mobile units communicate/coordinate with each other while utilizing a cross-band radio link. To utilize a cross-band radio link between the United State Park Police and the Alexandria, Metropolitan and Metro Transit Police Departments.
Lead Agency**:**	United States Park Police
Participating Agencies:	Alexandria Police Department, Metro Transit and Metropolitan Police Department (DC)
Resources::	USPP: Marked Cruiser, initial responders to the accident scene (simulated) on the George Washington (GW) Parkway just north of the sailing marina. Alexandria: Two police vehicles to simulate the diversion of northbound traffic on the GW Parkway at Slaters Lane. Lieutenant Kaluta will operate the first vehicle while the other will be operated by an Alexandria patrol officer. Bob Moseley will monitor the ACU-1000 and connect cross-band links when requested. At the start of the scenario, Mr. Moseley will be monitoring USPP Channel 3. MPDC: Marked Cruiser operated by Sergeant Al Sines to simulate the diversion of southbound traffic on the GW Parkway at the National Airport exit. Transit: An officer with a mobile radio at the Regan National Airport Metro Station to assist with traffic control at the airport.
Channels:	APD: OPS-2 USPP Tact Channel 3 MPD Command Channel Transit Main Operational Channel

6.5.2. Test Description

For this scenario, Mr. Moseley will be located at the ACU-1000 at APD at 2200 hours. The USPP, Alexandria, MPDC, and Transit officers will meet at the Washington Sailing Marina at 2145 hours. The unit deployments described below are depicted on the map in Figure 2.

A USPP marked unit(s) will respond to a multiple vehicular accident northbound on the George Washington Parkway just north of the Washington Sailing Marina. After finding north and south bound traffic blocked, the USPP officer will request assistance from the Alexandria and Metropolitan Police Departments for traffic control.

A cross-band link will first be established with Alexandria who will simulate the blocking of northbound traffic at Slaters Lane, diverting the traffic to US Route 1. A cross-band link will then be established with the MPDC unit who will simulate the blocking of southbound traffic at the exit to National Airport, diverting the traffic to the Airport and/or back to northbound GW Parkway.

Once the traffic control has been established the scenario will simulate that the diverted southbound traffic is looping around at the airport and attempting to reenter the parkway. At this time USPP will request a cross-band link with Transit and request they assist in the blocking of the return ramp from the airport to southbound GW Parkway (again only simulated). This will be a limited cross-band link at the end of the scenario to ensure that Transit's radio system is not tied up too long.

Throughout this mock scenario all participants will utilize "Plain English" radio communications. No "TEN" or other codes are to be used.

The units involved will identify themselves as follows:

- Alexandria: "Alexandria Unit 17" (Lt. Kaluta) and "Alexandria/Cruiser Number"
- USPP: "US Park Unit/Cruiser Number"
- MPDC: "DC Unit/Cruiser Number (Sgt. Sines)"
- Transit: "Transit/Cruiser Number"

Any officers involved in this operation should be briefed that this is a mock scenario. All officers should wait momentarily at the beginning of (when keying the microphone) and end of each transmission (once the carrier signal has dropped) before beginning their transmissions.

In this scenario, only the accident, the blocking of traffic, and the diversion of traffic north and south of the scene, will be simulated. Emergency equipment will not be used, and traffic will not be stopped, blocked or diverted.

6.5.3. Summary of Results

Operational Test #4 was conducted on October 20, 2000 at 2200 hours. Celeste Descoteaux of the AGILE Team operated the ACU-1000 during the test. Alexandria Police Lt. Roman Kaluta would coordinated field operations. The units involved in the test were APD unit 17, APD unit 344, MPD cruiser 9740, USPP car 50, and Metro Transit unit B6.

This test began when USPP's Channel 3 was cross-linked with APD Ops 2 channel. Interagency communications was initiated by USPP car 50 when he called the APD dispatcher to report a (fictitious) multiple car accident on the George Washington Parkway. USPP car 50 communicated directly with APD unit 17 and later with APD unit 344 to describe traffic rerouting on the Virginia side of the parkway. Communications between the units was loud and clear. Directions were easily understood.

In order to coordinate redirecting the traffic on the south end of the parkway, it was requested that MPD be added to the talk group. MPD's Command Channel was then linked creating a three way link within the ACU-1000. Communications between the units remained loud and clear. USPP car 50 communicated directly with MPD Cruiser 9740. Communications to and from APD 17 was also very successful. Units freely communicated with each other across all three systems.

APD unit 17 requested that Metro Transit be added to talk group. Metro Transit was linked into the system and a four-channel patch was established. However, neither the field units nor the AGILE base heard transmissions from Metro Transit unit B6. The Metro Transit unit apparently did hear APD 17 when he was asked to change his location and repeat his transmission. For one brief moment Metro Transit B6 was heard but reliable communications to and from Metro Transit were not established.

APD unit 17 individually called each of the other units and asked that they respond to the sailing marina. The test was then concluded.

With the exception of Metro Transit, unit-to-unit communications were loud and clear. As one of the officers involved in the test would later say "it was just like they were on our radio system."

Some of the repeater sites for the Metro Transit PD were non-operational during the test (although this information was not available at the time of the test). Metro Transit units heard their dispatcher and the dispatcher heard the field units, but for some time field units did not hear each other. This inability to communicate with Metro Transit was probably the result of the problems that they were experiencing with their system.

6.5.4. Resulting Modifications to the Gateway Subsystem

A test was conducted with Metro Transit using a Bendix King VHF radio to determine if the COR settings would decrease the problems experienced with their radio system during interconnection with other agencies. The squelch tail at the end of the transmissions was still present with the Bendix King radio, similar to that experienced with the MCS-2000 radio. It appears that the transmissions from Metro Transit's repeater sites using carrier squelch (rather than PL tones) is the cause of the problem. One possible solution is for Metro Transit to install PL on the repeater that transmits to the Gateway Subsystem; however, this would be a modification to Metro Transit's radio system and is therefore beyond the scope of the AGILE project.

The HSP-2 card was replaced with a new card, confirming that the low volume associated with the HSP-2 card was caused by a failure within the original HSP-2 card.

A. "PING PONG" EFFECT

By far the most challenging technical aspect of the deployment of the ACU-1000 was in interfacing with the repeater systems of the participating agencies. In systems in which a radio interfaced to the ACU-1000 is transmitting to a receiver site through a repeater, due to the length of the squelch tail, a repeater could stay up long enough to bring the radio connected to the ACU-1000 back up before the repeater goes down. Then because the radio is back up, the repeater could come back up, bringing the radio back up; and so on. This effect is referred to as the "ping pong" effect. In this appendix, we provide a more detailed discussion of the "ping pong" effect and how it was addressed in the Gateway Subsystem.

A.1 Explanation of the "Ping Pong" Effect

To understand the "ping pong" effect, first consider the basics of repeaters. Repeaters are full-duplex systems, meaning that they transmit and receive at the same time, but on different frequencies. When the repeater receiver gets a signal from a mobile unit, it rebroadcasts (repeats) this signal on the repeater transmitter. The repeater receiver usually operates with Carrier Operated Relay (COR) which means that the repeater transmitter is keyed as soon as a carrier signal with appropriate PL tone is heard at the repeater receiver. When carrier and PL tone is received at the repeater, the transmitter keys (even if no voice audio is present). To compensate for radio propagation delays and equipment latencies through the repeaters, the repeaters have adjustable "squelch tails," i.e. an adjustable amount of time when the repeater transmitter stays on after a mobile unit stops transmitting. It is called a squelch tail because the repeater transmitter causes any mobile unit receiver to break squelch[4] during this "no-audio" delay time after unkeying the mobile transmitter. This results in an audible noise sound on the radio.

The ACU-1000 functions as a full-duplex repeater. It is a crossband repeater if the connected radios operate in more than one frequency band. Conceptually, the function of the ACU-1000 system is the same as described above, i.e., it receives a signal on one radio frequency and retransmits on another radio frequency.

Using the ACU-1000 with repeater systems is equivalent to connecting two repeaters back to back. A "ping pong" effect occurs if one repeater is still transmitting and the other repeater is receiving when no audio signal is present. In other words, the squelch tail of one repeater can cause the other repeater to turn on momentarily. The latencies and hang times of each repeater can cause their respective transmitters and receivers to alternately cycle on and off indefinitely. This oscillation is called the ping pong effect because it seems as if a phantom signal is bouncing like a ping pong ball between each repeater.

A.2 Gateway Subsystem Implementation to Address the "Ping Pong" Effect

The ACU-1000 DSP-1 cards offer three keying options for the transmitter:

- COR as described above;

[4] "Break squelch" means a radio signal is present at sufficient strength above the adjustable squelch threshold to be heard through the radio speakers/headset.

- Voice Operated Transmit (VOX) which turns on the Tx keying signal only when the receiver breaks squelch; and
- Voice Modulation Recognition (VMR) which turns on the Tx keying signal when the receiver breaks squelch AND the ratio of the lower audio frequencies to the higher audio frequencies in the signal is sufficiently strong to indicate voice is present.

VOX and VMR have adjustable sensitivity settings to determine how strong a signal is needed to turn on these functions. They have adjustable initial delay times to prevent loss of the first syllables of the voice call. The DSP-1 cards also have an adjustable hang time which functions much the same way as the "squelch tail" delay of a conventional repeater as described above. In addition, the DSP-1 cards have an adjustable parameter called the "COR Inhibit Time after PTT" which will prevent the radio receiver from sending a from Transmit key signal while the repeater squelch tail is on.

As a result of the operational tests, the ACU-1000 in the Gateway Subsystem was programmed with the following parameters:

1) The COR Type for all DSP-1 cards was set to VMR.
2) The VMR threshold was set to a value of 2 (Med2) for all DSP-1 cards except the one interfacing with the Metro Transit radio (due to other issues with the Metro Transit radio system).
3) The Hangtime was set to a value of 4 (975 msec) for all DSP-1 cards except the one interfacing with the Metro Transit radio (due to other issues with the Metro Transit radio system).
4) The "COR Inhibit Time after PTT" was set to 3 (400 ms).
5) The "Hang Up Button" (HUB) of the MCS-2000 radio was set to "Disabled" for each of the MCS-2000 radios. (The MCS-2000 HUB setting overrides the "Tone Squelch" of the radio when the HUB is enabled, thus inhibiting termination of the squelch tail.)

A.3 General Approach to Addressing the "Ping Pong" Effect

While the approach described above effectively addressed the "ping pong" effect of interfacing the Gateway Subsystem to other repeaters, it is not necessarily the best approach for all such interfaces. The optimum solution is a function of several factors, including the types of radios used, the length of the squelch tails of the repeaters with which an ACU-1000 is interfacing, noise characteristics of the radio systems with which the ACU-1000 is interfacing, and acceptable delays within the system. For example, the Hardware COR setting minimizes delays (assuming that the radio interfaced to the DSP-1 card has a hardware COR signal) but can transmit "false keying"—signals that bring up the repeaters even when no voice is being transmitted. VMR ensures that transmissions that key up the transmitters are voice transmissions, but at a cost of additional delays (necessary to identify the voice modulation) and the possibility of losing some voice transmissions (depending on the VMR threshold setting).

We recommend that any use of the ACU-1000 interfacing with repeater systems be preceded by a set of operational tests involving the parameters identified in Section A.2 to determine the appropriate settings for a specific situation.

B. ACU-1000 DSP PARAMETER DEFINITIONS

Parameter settings in the ACU-1000 radio interface (DSP) cards are typically entered as a number from 0 to 9. The actual values of these parameters are defined in Table 10. Default settings are highlighted.

Table 10: ACU-1000 DSP Parameters

DSP Parameter	Parameter Definitions
TX Level	0 = -26dBm, 1 = -20dBm, 2 = -16dBm, 3 = -12dMB, 4 = -8dBm, 5 = -4dBm, 6 = 0bDm, 7 = 4dBm, 8 = 8dBm, 9 = 12dBm
RX Level	0 = 12dBm, 1 = 8dBm, 2 = 4dBm, 3 = 0dMB, 4 = -4dBm, 5 = -8dBm, 6 = -12bDm, 7 = -16dBm, 8 = -20dBm, 9 = -26dBm
Squelch Type	0=COR, 1=VMR, 2=Reserved, 3=VOX
VOX/VMR threshold	0 = Low (Highest Sensitivity), 1 = Med1, 2 = Med2, 3 = High (Lowest Sensitivity)
DTMF Mute Timer	0 = Off, 1 = 0.5 sec, 2 = 1 sec, 3 =1.5 sec, 4 = 2 sec, 5 = 2.5 sec, 6 = 3 sec, 7 = 3.5 sec, 8 = 4 sec, 9 = 4.5 sec
Security Level	0 = Not secure, 1 = Least secure, 9 = Most secure
VOX/VMR Hangtime	VOX: 0 = 175ms, 1 = 375ms, 2 = 575ms, 3 = 775ms,4 = 975ms, 5 = 1.175 sec, 6 = 1.375 sec, 7 = 1.575 sec VMR: Less than 775ms not allowed, 1, 2, 3 = 775ms, 4 = 975ms, 5 = 1.175 sec, 6 = 1.375 sec, 7 = 1.575 sec
Audio Equalizer	
Positive/Negative COR	0 = Active low, 1 = Active High
COR Sampling Enabled/Disabled	0 = disabled, 1 = enabled
Audio Delay Time	VOX: 0 = 20ms, 1 = 60ms, 2 = 100ms, 3 = 140ms, 4 = 180ms, 5 = 220ms, 6 = 260ms, 7 = 300ms VMR: Less than 220ms not allowed, 0, 1,2,3,4,5 = 220ms, 6 = 260ms, 7 = 300ms
Half/Full Duplex	0 = full, 1 = half
COR Sampling Initial Delay Time	0 = 2 sec, 1 = 4 sec, 2 = 6 sec, 4 = 10 sec, 5 = 12 sec, 6 = 14 sec, 7 = 16 sec, 8 = 18 sec, 9 = 20 sec
COR Sampling Interval	0 = 1 sec, 1 = 2 sec, 2 = 3 sec, 4 = 5 sec, 5 = 6 sec, 6 = 7 sec, 8 = 9 sec, 9 = 10 sec
Squelch On/Off	
COR Sampling Width	0 = 50 ms, 1 = 100ms, 2 = 150ms, 3 = 200ms, 4 = 250ms, 5 =

DSP Parameter	Parameter Definitions
	300ms, 6 = 350ms, 7 = 400ms, 8 = 450ms, 9 = 500 ms
Keying Transmit Tones	0 = none, 1 = 1950 Hz Continuous, 2 = 2175 Hz Continuous
PTT/COR Priority	0 = COR Priority, 1 = PTT Priority
Peaker Value	0 =off, 1 = Minimum …..9 = Maximum
COR Inhibit Time	0 = None, 1 = 100ms, 2 = 200ms, 3 = 400ms, 4 = 800ms, 5 = 1 sec, 6 = 2 sec, 7 = 3 sec, 8 = 4 sec, 9 = 5 sec
Keying Tone Amplitude	0 = -6 dB, 1 = -9 dB, 2 = -12 dB, 3 = -15 dB
DTMF Command Disabled/Enabled	0 = disabled, 1 = enabled
Output Control User/Local	0 = User control via serial commands, 1 = local control by module
Radio Type	0 = Standard, non-trunking; 1 = Type 1 trunking; 2 through 9 reserved

C. DETAILED FUNCTIONAL TEST RESULTS

This section includes the procedures associated with the specific functional tests that were performed to ensure proper operation of the Communications Interoperability Capability Gateway Subsystem. These tests are organized into test sets, which progressively test the capabilities of the subsystem. The tests were planned as follows:

Set A	Tests 1 – 4:	Receive only – no links
Set B	Tests 5 – 8:	Receive only, audio link to PSTN-1, no transmissions
Set C	Tests 9 – 11:	Transmission tests to APD's Zebra (currently non-operational) channel
Set D	Tests 12 – 15:	Scripted transmission tests to communications centers, No links
Set E	Tests 16 – 19:	Scripted transmission tests direct to field units. No links
Set F	Tests 20 - 21:	Tests links and unit to unit transmissions
Set G	Test 22:	Test link within same band (USPP – Metro Transit)
Set H	Test 23:	Link multi bands with units side by side.

Procedures and results for each test set are defined in a subsection below. For each test, the results are shown in green type in a box. Deviations from planned test procedures are shown in red. In the scripts for the tests, the scripting for the AGILE test operator is shown in blue type. Also, when the specific unit is not known a priori, the phrase "????" is shown in the script. During the actual test, the appropriate unit designation was used.

Two Test Sets were unable to be completed during the functional test period. Test Set B, which included a test of the telephone interface, was deferred until the telephone line is connected to the ACU-1000. Test Set H, which is a test in which all agencies are connected together, was not completed during the functional test period and has been incorporated into the operational testing.

C.1 Functional Test Set A: Receive Only Single Channel

The purpose of the first functional test set is to ensure that the gateway subsystem can receive transmissions from the four participating land mobile radio systems. For these tests, no switching of the audio is required. The procedure for each of the four tests is identical (other than the radio in use). The test operator will turn on the appropriate radio, set the channel to an active channel of the agency, and listen to verify receipt of transmissions from each radio system. Upon completion of the test, the test operator will turn off the radio.

The test could not be executed as described above, because speakers for the individual radios were not yet implemented. To allow observers to hear transmissions being received by the radios interfaced to the ACU-1000, it was necessary for the operator to establish a connection in the ACU-1000 between the radio and the HSP2 module, and listen through the handset.

Specific functional tests are as follows:

Test #1: Monitor receive capabilities on the APD channel.

Although it was a little after 0500 hours, after a short wait there was traffic to be heard on the APD radio. APD's signal was loud and clear.

Test #2: Monitor receive capabilities on the MPD channels.

The City Wide 1 channel was monitored first, but no traffic was heard. The radio was switched to various MPD channels and eventually traffic was heard from an MPD 6th District unit. The MPD's Sixth District is located on Benning Road in NE Washington and that repeater was not a site targeted in the design of the Gateway Subsystem. (The directional antenna of the subsystem is aimed at the MPD tower site located at the Fourth District on Georgia Ave in NW Washington, DC.) There was some static on the channel. The unit was "readable" and the cause of the static was undetermined.

Test #3: Monitor receive capabilities on the Metro Transit channel.

There was no traffic on the Metro Transit channel. However, their dispatcher was called via landline and asked to conduct a radio test with one of their field units. They had designated "C-51" as the unit to test throughout these procedures. "C-51" answered the radio test and both he and the dispatcher were loud and clear.

Test #4: Monitor receive capabilities on the USPP channels.

Two USPP officers were present at the APD site. No traffic was initially heard. The dispatch center was contacted via landline and asked to conduct a radio test with a field unit on USPP's Channel 2 Main. The USPP unit responded "10-2" which means "Loud and Clear".

C.2 Functional Test Set B: Receive Only Through PSTN Connection

The second set of functional tests is to exercise the ACU-1000 switching capability while still operating in a receive only mode to avoid transmissions on an operational channel. Audio will be switched from a receiving radio to the PSTN interface.

The procedures for the tests in this functional test set are identical (other than the radio in use). The test operator will turn on the appropriate radio, set the channel to an active channel of the agency. Next the test operator will link the radio to the PSTN interface using the graphical user interface (GUI) of the ACU-1000 console interface. The test operator will then listen through the Handset to verify receipt of audio. Upon completion of the test, the test operator will turn off the radio, then disconnect the link between the PSTN interface and the radio interface. (Note that it is important to turn off the radio first to avoid the over-the-air "Disconnecting" message of the ACU-1000.)

Specific functional tests are as follows:

Test #5: Link PSTN-1 connection to APD channel and conduct listen only tests through the ACU-1000.

Test #6: Link PSTN-1 connection to MPD channel and conduct listen only tests through the ACU-1000.

Test #7: Link PSTN-1 connection to Metro Transit channel and conduct listen only tests through the ACU-1000.

Test #8: Link PSTN-1 connection to USPP channel and conduct listen only tests through the ACU-1000.

The PSTN interface was not yet implemented, so it was not possible to execute the tests as described above. Since Tests 1-4 were conducted using the HSP2 interface, the primary capability to be exercised in this test set, the ability to switch audio through the ACU-1000, was already verified in Test Set A.

C.3 Functional Test Set C: Receive and Rebroadcast on APD Non-Operational Channel

The third set of functional tests utilizes a non-operational frequency licensed to APD to exercise the gateway subsystem without transmitting on any operational channel. Audio will be received from each of the three other agencies and retransmitted on APD's Zebra channel.

The procedures for the tests in this functional test set are identical (other than the radio in use). The test operator will turn on the appropriate radio, set the channel to an active channel of the agency. The test operator will then verify that the APD radio is on and set to the Zebra channel. Next the test operator will link the other agency radio to the APD radio using the graphical user interface (GUI) of the ACU-1000 console interface. The test operator will then listen to the APD radio to verify receipt of audio. Upon completion of the test, the test operator will turn off the radio, then disconnect the link between the radios. (Note that it is important to turn off the radio first to avoid the over-the-air "Disconnecting" message of the ACU-1000.)

Specific functional tests are as follows:

Test #9: Link MPD City Wide-1 (or other in use channel if CW-1 is not being used) to the currently non-operational APD Zebra channel through the ACU-1000. MPD's traffic should be rebroadcast on the APD Zebra channel. For this test NO TRANSMISSIONS will be made over the MPD channel.

There was no traffic on MPD City Wide 1. The channel was not in use during the midnight hour. The test was altered to link MPD's 2nd District to APD's Zebra channel. The link was successful and MPD's traffic could be heard on a handheld APD unit.

Test #10: Link Metro Transit's channel to the currently non-operational APD Zebra channel through the ACU-1000. Metro's traffic should be rebroadcast on the APD Zebra channel. For this test NO TRANSMISSIONS will be made over the Metro channel.

There was no traffic on the Metro Transit channel. Rather than force traffic, this test was deferred in favor of Test #22, which includes receipt of Metro Transit transmissions and rebroadcast to active channels.

Test #11: Link USPP's Channel 2 Main to the currently non-operational APD Zebra channel through the ACU-1000. USPP's traffic should be rebroadcast on the APD Zebra channel. For this test NO TRANSMISSIONS will be made over the USPP channel.

There was no traffic on the USPP channel. However, courier signals were occasionally noted. It sounded like someone keying a microphone, but not saying anything. This test was also deferred in favor of Test #22, which includes receipt of USPP transmissions and rebroadcast to active channels.

C.4 Functional Test Set D: Communications Between Gateway Subsystem and Agency Dispatches

This functional test involves transmission over the air between the gateway subsystem and the dispatch centers of the participating agencies. Test procedures and scripted communications for each test are documented in a subsection below.

C.4.1 Test #12: Transmissions Between Gateway Subsystem and APD Dispatch

From the 800 MHz trunked radio in the ACU-1000 switch, contact the APD dispatcher on the active channel for a radio test.

Scripted communications will be as follows:

"AGILE-1 to APD Communications…"

Acknowledgement from APD

"This is test 12 of the crossband communications switch. How do you copy this radio?"

Reply from APD

"Thank you, AGILE-1 out."

A link was established between the HSP-2 module of the ACU-1000 and the APD radio. APD dispatch was called using the handset of the ACU-1000. APD dispatch reported hearing the signal "Loud and Clear."

C.4.2 Test #13: Transmission Between Gateway Subsystem and MPD Dispatch

From a UHF radio in the ACU-1000 switch, contact the MPD dispatcher on City Wide 1 for a radio test.

Scripted communications will be as follows:

"AGILE-1 to MPD Communications…"

Acknowledgement from MPD

"This is test 13 of the crossband communications switch. How do you copy this radio?"

Reply from MPD

"Thank you, AGILE-1 out."

A link was established between the HSP-2 module of the ACU-1000 and the MPD radio tuned to City Wide 1. MPD dispatch was called using the handset of the ACU-1000. MPD did not originally answer the call. The MPD communications center was called via landline. No one was monitoring the City Wide 1 channel. MPD communications asked that the test be conducted on the 1D zone. MPD was called on the 1D channel and reported hearing the signal as "readable."

C.4.3 Test #14: Transmission Between Gateway Subsystem and Metro Transit Dispatch

From a VHF radio in the ACU-1000 switch, contact the Metro dispatcher on Metro's channel for a radio test.

Scripted communications will be as follows:

"AGILE-1 to Metro Communications…"

Acknowledgement from Metro

"This is test 14 of the crossband communications switch. How do you copy this radio?"

Reply from Metro

"Thank you, AGILE-1 out." .

A link was established between the HSP-2 module of the ACU-1000 and the Metro Transit radio. Metro dispatch was called using the handset of the ACU-1000. Metro Transit communications reported hearing the signal "Loud and Clear." Reception through the ACU-1000 handset was a little broken.

C.4.4 Test #15: Transmission Between Gateway Subsystem and USPP Dispatch

From a VHF radio in the ACU-1000 switch, contact the Park Police dispatcher on the USPP channel for a radio test.

Scripted communications will be as follows:

"AGILE-1 to USPP Communications…"

Acknowledgement from USPP

"This is test 15 of the crossband communications switch. How do you copy this radio?"

Reply from USPP

"Thank you, AGILE-1 out." .

Since two USPP officers were present for the test, the handset was turned over to USPP Sgt. Mike Snowden. A link was established between the HSP-2 module of the ACU-1000 and the USPP dispatch. Using the handset of the ACU-1000, Sgt. Snowden asked for a radio test. USPP dispatch reported hearing the signal "10-2" or "Loud and Clear."

If adjustments are required to the settings of the ACU-1000 steps 12 through 15 may be repeated as necessary.

C.5 Functional Test Set E: Communications Between Gateway Subsystem and Field Unit

In testing the ACU-1000's ability to communicate with field units of each of the jurisdictions, the communications centers will be called first on their operational frequencies via the ACU-1000. The dispatcher will then be asked to select an in-service field unit to switch over to a tactical channel. Field units will be randomly selected and have no training on this test. Dispatchers will be aware that tests will be conducted, but will receive no training on the test procedures. With the field units standing by on their tact channels, a radio test to each will be conducted from the AGILE switch.

C.5.1 Test #16: Transmission Between Gateway Subsystem and APD Officer in Car

From the 800 MHz trunked radio in the ACU-1000 switch, contact the APD dispatcher on the active channel to have a field unit switch to tactical channel.

Scripted communications will be as follows:

"AGILE-1 to APD Communications…"

Acknowledgement from dispatcher.

"This is test 16 of the crossband communications switch. We would like to communicate directly with a field unit for a communications test. Would you have a field unit switch to OPS-3 for a radio test?"

Reply from dispatcher.

"Thank you, AGILE-1 switching to OPS-3."

With radio set to OPS-3

"AGILE-1 to ????"

Unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from unit.

"What is your location?"

Reply from unit.

"Thank you for assistance. You may return to service. AGILE-1 out" .

The APD dispatcher was called using the ACU-1000 handset. Unit 121 was asked to switch to the tact channel. The field unit was called directly from the ACU-1000 on the tact channel OPS-3. The unit reported hearing the radio test "Loud and clear." Unit 121 was located along Braddock Road.

C.5.2 Test #17: Transmission Between Gateway Subsystem and MPD Field Unit

From a UHF radio in the ACU-1000 switch, contact the MPD dispatcher on City Wide -1 to go direct to a field unit.

Scripted communications will be as follows:

"AGILE-1 to MPD Communications…"

Acknowledgement from dispatcher.

"This is test 17 of the crossband communications switch. We would like to communicate directly with a field unit for a communications test. Would you have a field unit switch to the Command Channel for a radio test?"

Reply from dispatcher.

Unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from unit.

"What is your location?"

Reply from unit.

"Thank you for assistance. AGILE-1 out" .

The MPD 1D (First District) dispatcher was called using the ACU-1000. MPD unit NI-16 switched to City Wide 1. The field unit reported that the radio test was "readable, but there was a humming noise in the background." (The handset of the ACU-1000 is in close proximity of a mounted fan installed in the rack.) The unit was located at South Capitol and M St. in SE Washington.

C.5.3 Test #18: Transmission Between Gateway Subsystem and Metro Transit Field Unit

From a VHF radio in the ACU-1000 switch, contact the Metro Transit dispatcher on their active channel to go direct to a field unit.

Scripted communications will be as follows:

"AGILE-1 to Metro Communications…"

Acknowledgement from dispatcher.

"This is test 18 of the crossband communications switch. We would like to communicate directly with a field unit for a communications test?"

Reply from dispatcher.

Unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from unit.

"What is your location?"

Reply from unit.

"Thank you for assistance. AGILE-1 out" .

Since there was no tact channel available to the Metro Transit police, this test was conducted on their operational channel. Using the ACU-1000 handset, a Metro Transit unit was given a radio check. That unit reported receiving "Loud and clear." The unit was located at 4th and Independence Ave. in NW Washington, DC.

Our reception of the Metro Transit unit had some static. At the time we were using VHF radio #6. The test was rerun using VHF radio #7.

This time the unit was located at New York and Blandensburgh Rd. in NE Washington. The signal from the unit was "Loud and Clear." It was undetermined whether the clearer signal resulted from a unit with a better field radio, or if the antenna and/or radio #7 produced the better reception.

C.5.4 Test #19: Transmission Between Gateway Subsystem and USPP Field Unit

From a VHF radio in the ACU-1000 switch, contact the USPP dispatcher on the USPP channel to go direct to a field unit.

Scripted communications will be as follows:

"AGILE-1 to USPP Communications…"

Acknowledgement from dispatcher.

"This is test 19 of the crossband communications switch "We would like to communicate directly with a field unit for a communications test. Would you have a field unit switch to the Tact-3 for a radio test?"

Reply from dispatcher.

Unit Acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from unit.

"What is your location?"

Reply from unit.

"Thank you for assistance. AGILE-1 out"

The USPP dispatcher was called and field unit 145 switched to Tact-3. Unit 145 reported hearing the signal "Loud and Clear". This test was conducted using VHF radio #7, which was the clearer radio from test #18. The unit was located at 15th and Independence Ave., SW Washington, DC.

This test was rerun using VHF radio #6 and the signal was reported as "Loud and clear." Our reception was also "Loud and clear."

C.6 Functional Test Set F: Communications Between Two Units on Different Bands

This set of functional tests verifies the capability for the ACU-1000 to connect field units from one agency to field units of another agency. In each case, the dispatcher for each agency is contacted and requested to have a field unit switch to the channel being used for the test. Then after a radio check between the field units, each field unit is asked how well the transmission is received. Test Set F includes tests that involve two different frequency bands.

C.6.1 Test #20: Communication Between 800 MHz and UHF Systems

Contact APD and have an APD unit switch to OPS-3 for a radio test. Ask that unit to standby on OPS-3. Contact MPD and have a unit switch to their Command channel for a radio test. Ask that unit to standby to be linked to APD ????.

Scripted communications will be as follows:

"AGILE-1 to APD Communications…"

Acknowledgement from APD dispatcher.

"This is test 20 of the crossband communications switch. Would you please have a unit switch to OPS-3 for a radio communications test.?"

Reply from APD dispatcher.

"Thank you, AGILE-1 switching to OPS-3."

With radio set to OPS-3

"AGILE-1 to ????"

APD unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from APD unit.

"What is your location?"

Reply from APD unit.

"???? Please standby on OPS-3 while we raise an MPD unit."

Switch ACU-1000 to MPD radio.

"AGILE-1 to MPD Communications…"

Acknowledgement from MPD dispatcher.

"This is test 20 of the crossband communications switch. Would you please have a unit switch to the Command Channel or City Wide 1, whichever is not in use, for a radio communications test."

Reply from MPD dispatcher.

"Thank you, AGILE-1 switching to City Wide 1 {or Command Channel}."

With radio set to Command Channel

"AGILE-1 to ????"

MPD unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from MPD unit.

"What is your location?"

Reply from MPD unit.

"???? Please standby on the City Wide 1 {or Command Channel} while we link Alexandria unit ???? into the channel."

With 800 MHz radio set to OPS-3 and the UHF radio set to the Command Channel initiate the link between the two radios.

"APD ???? This is AGILE-1 - How do you copy this radio, now?

Reply from APD unit.

"MPD ???? - How do you copy this radio, now?

Reply from MPD unit.

"MPD ???? – where you able to copy APD ????"

Reply from MPD unit.

"MPD ???? – how would you characterize APD ???? signal strength?"

Reply from MPD unit.

"APD ???? – where you able to copy MPD ????"

Reply from APD unit.

"APD ???? – how would you characterize MPD ???? signal strength?"

Reply from APD unit.

"Copy APD ????. Could you attempt to go direct to MPD ????."

Monitor unit-to-unit transmissions.

"APD ???? at your convenience please call (202 812-6114) landline. Thank you for your assistance."

Reply from APD unit.

"MPD ???? at your convenience please call (202 812-6114) landline. Thank you for your assistance."

Reply from MPD unit.

APD unit 112 was switched to APD's Ops 1 channel. He was located at Queen and Fairfax Street in Alexandria, VA. APD 112 copied "Loud and clear." MPD communications was called and MPD unit 1021 was switched to City Wide 1. The MPD unit was located on Second Street, SW Washington. MPD unit 1021 copied "Loud and clear." There was traffic on City Wide 1. APD unit 112 called MPD unit 1021. The field units were able to communicate but reported a little static and possible feedback. An unknown audible alarm was sounding in the equipment room in close proximity of the ACU-1000.

C.6.2 Test #21: Communication Between 800 MHz and VHF Systems

Contact APD and have an APD unit switch to OPS-3 for a radio test. Ask that unit to standby on OPS-3. Contact USPP and have a unit switch to Tact - 4 for a radio test. Ask that unit to standby to be linked to APD ????.

Scripted communications will be as follows:

"AGILE-1 to APD Communications…"

Acknowledgement from APD dispatcher.

"This is test 21 of the crossband communications switch. Would you please have a unit switch to OPS-3 for a radio communications test.?"

Reply from APD dispatcher.

"Thank you, AGILE-1 switching to OPS-3."

With radio set to OPS-3

"AGILE-1 to ????"

APD unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from APD unit.

"What is your location?"

Reply from APD unit.

"???? Please standby on OPS-3 while we raise a USPP unit."

Switch ACU-1000 to USPP radio.

"AGILE-1 to USPP Communications…"

Acknowledgement from USPP dispatcher.

"This is test 21 of the crossband communications switch. Would you please have a unit switch to the Tact – 3 for a radio communications test."

Reply from USPP dispatcher.

"Thank you, AGILE-1 switching to Tact-3."

With radio set to USPP Tact-4

"AGILE-1 to ????"

USPP unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from USPP unit.

"What is your location?"

Reply from USPP unit.

"???? Please standby on Tact-3 while we link Alexandria unit ???? into the channel."

With 800 MHz radio set to OPS-3 and the VHF radio set to the Tact-4 initiate the link between the two radios.

"APD ???? This is AGILE-1 - How do you copy this radio, now?

Reply from APD unit.

"USPP ???? - How do you copy this radio, now?

Reply from USPP unit.

"USPP ???? – where you able to copy APD ????"

Reply from USPP unit.

"USPP ???? – how would you characterize APD ???? signal strength?"

Reply from USPP unit.

"APD ???? – where you able to copy USPP ????"

Reply from APD unit.

"APD ???? – how would you characterize USPP ???? signal strength?"

Reply from APD unit.

"Copy APD ????. Could you attempt to go direct to USPP ????."

Monitor unit to unit transmissions.

"APD ???? at your convenience please call (202 812-6114) landline. Thank you for your assistance."

Reply from APD unit.

"USPP ???? at your convenience please call (202 812-6114) landline. Thank you for your assistance." .

Reply from USPP unit.

USPP unit 400, located in Greenbelt, MD, was switched to their Tact-3 channel. APD unit 112 was switched to OPS 3 channel. APD unit 112 was asked to contact USPP unit 400. USPP unit 400 reported hearing the APD unit "Loud and Clear", but a little "choppy."

C.7 Functional Test Set G: Communications Between Two Units on Same Band

C.7.1 Test #22: Communications Between USPP and Metro Transit

Contact USPP and have an USPP unit switch to Tact-4 for a radio test. Ask that unit to standby on Tact-4. Link USPP Tact-4 with Metro Transit (assuming Tact-4 is quiet). Contact Metro dispatcher and have them raise the USPP unit for a radio test.

Scripted communications will be as follows:

"AGILE-1 to USPP Communications…"

Acknowledgement from USPP dispatcher.

"This is test 22 of the crossband communications switch. Would you please have a unit switch to Tact-4 for a radio communications test.?"

Reply from USPP dispatcher.

"Thank you, AGILE-1 switching to Tact-4."

With radio set to Tact-4

"AGILE-1 to ????"

USPP unit acknowledgement.

"???? We are testing a crossband communications switch. How do you copy this radio?

Reply from USPP unit.

"What is your location?"

Reply from USPP unit.

"???? Please standby on Tact-4 while we link this channel with the Metro Transit Police."

Link USPP Tact-4 and Metro Transit

"AGILE-1 to Metro Communications…"

Acknowledgement from Metro Transit dispatcher.

"This is test 22 of the crossband communications switch. We have USPP unit linked into this channel. Would you please try to raise ???? for a radio test.

Reply from Metro Transit dispatcher.

Radio test by Metro dispatcher

"Thank you dispatcher. Could you raise one of your units and see if they were able to copy USPP ????."

Reply from Metro Transit dispatcher.

Inquiry to Metro unit by dispatcher.

"What is that units location, sir?"

Reply from Metro Transit dispatcher.

Inquiry to Metro unit by dispatcher.

"Thank you dispatcher. AGILE-1 out."

Break link

On USPP Tact-4

"USPP ???? were you able to copy Metro Transit field units"

Reply from USPP unit.

"USPP ???? ???? at your convenience please call (202 812-6114) landline. Thank you for your assistance."

This test was executed slightly differently than as described in the script. The connection established in the previous test was left intact, and a connection to the Metro transit channel was added, resulting in a four-way connection including Metro Transit, USPP, APD, and the ACU-1000 handset.

Metro Transit unit C51, located at the Smithsonian Mall, responded.

A ping-pong effect was noted when Metro Transit, USPP, and APD radios were linked together. For a series of about five times, one radio would transmit a courier then the other would transmit a courier. The squelch type was changed from VOX to VMR and this seemed to solve the problem.

The test was then conducted again. USPP unit 400 apparently left the channel. APD unit 112 and Metro Transit unit C51 reported they could copy but that the transmission was somewhat "garbled." USPP later joined the conversation and reported hearing the signal "Loud and Clear."

The APD trunking radio was removed from the link, leaving USPP and Metro Transit connected as described in the plan for this test. USPP unit 400 and Metro Transit unit C51 were then able to converse. They reported strong, clear signals.

C.8 Functional Test Set H: Communications Among Three Field Units

C.8.1 Test #23: Communications Between USPP, Metro, and Metro Transit

One of the test team members will respond to the Mall subway station in Washington, DC. This is a tri-jurisdiction location with Metro Transit handling the subway, USPP handling the Mall and MPD with joint coverage. From that location have a unit from each of the jurisdictions respond. MPD will be asked to switch to the Command Channel, USPP to Tact-4. USPP tact-4, MPD Command and Metro Transit will all be linked together. Limit radio tests will then be conducted. During the communications test observations about unit-to-unit delays, etc. will be monitored at the scene.

Due to time limitations, this test was deferred until the first operational test.

D. FUNCTIONAL TEST ACU-1000 LOG FILE

This section includes the log file from the ACU-1000. This file shows each connection that was made during the course of test. Following the file, we have included an annotated version of the file, mapping the connections to the individual tests described in Section 5. “Grayed out” entries are connections prior to or following the actual functional test.

07/21/2000-05:09:37	-	HSP2-1	Connected to	DSP1-6	1	----	
07/21/2000-05:17:39	-	DSP1-6	Disconnected			1	----
07/21/2000-05:17:39	-	HSP2-1	Disconnected			1	----
07/21/2000-05:23:07	-	HSP2-1	Connected to	DSP1-1	1	----	
07/21/2000-05:24:17	-	DSP1-1	Disconnected			1	----
07/21/2000-05:24:17	-	HSP2-1	Disconnected			1	----
07/21/2000-05:25:00	-	HSP2-1	Connected to	DSP1-3	1	----	
07/21/2000-05:25:45	-	DSP1-3	Disconnected			1	----
07/21/2000-05:25:45	-	HSP2-1	Disconnected			1	----
07/21/2000-05:25:57	-	HSP2-1	Connected to	DSP1-4	1	----	
07/21/2000-05:27:05	-	DSP1-4	Disconnected			1	----
07/21/2000-05:27:05	-	HSP2-1	Disconnected			1	----
07/21/2000-05:27:15	-	HSP2-1	Connected to	DSP1-6	1	----	
07/21/2000-05:29:01	-	DSP1-6	Disconnected			1	----
07/21/2000-05:29:01	-	HSP2-1	Disconnected			1	----
07/21/2000-05:29:08	-	HSP2-1	Connected to	DSP1-5	1	----	
07/21/2000-05:31:30	-	HSP2-1	Disconnected			1	----
07/21/2000-05:31:30	-	DSP1-5	Disconnected			1	----
07/21/2000-05:34:14	-	DSP1-1	Connected to	DSP1-3	1	----	
07/21/2000-05:35:56	-	DSP1-1	Disconnected			1	----
07/21/2000-05:35:56	-	DSP1-3	Disconnected			1	----
07/21/2000-05:36:10	-	DSP1-1	Connected to	DSP1-6	1	----	
07/21/2000-05:38:01	-	HSP2-1	Connected to	DSP1-1	1	----	
07/21/2000-05:38:22	-	DSP1-6	Disconnected			1	----
07/21/2000-05:38:52	-	DSP1-5	Connected to	DSP1-1	1	----	
07/21/2000-05:39:59	-	DSP1-5	Disconnected			1	----
07/21/2000-05:41:57	-	DSP1-1	Disconnected			1	----
07/21/2000-05:41:57	-	HSP2-1	Disconnected			1	----
07/21/2000-05:42:07	-	HSP2-1	Connected to	DSP1-3	1	----	
07/21/2000-05:46:53	-	DSP1-3	Disconnected			1	----
07/21/2000-05:46:53	-	HSP2-1	Disconnected			1	----
07/21/2000-05:47:08	-	HSP2-1	Connected to	DSP1-5	1	----	
07/21/2000-05:49:51	-	DSP1-5	Disconnected			1	----
07/21/2000-05:49:51	-	HSP2-1	Disconnected			1	----
07/21/2000-05:49:55	-	HSP2-1	Connected to	DSP1-1	1	----	
07/21/2000-05:51:42	-	DSP1-1	Disconnected			1	----
07/21/2000-05:51:42	-	HSP2-1	Disconnected			1	----
07/21/2000-05:51:50	-	HSP2-1	Connected to	DSP1-3	1	----	
07/21/2000-05:55:45	-	DSP1-3	Disconnected			1	----
07/21/2000-05:55:45	-	HSP2-1	Disconnected			1	----
07/21/2000-05:55:51	-	HSP2-1	Connected to	DSP1-5	1	----	
07/21/2000-05:58:21	-	DSP1-5	Disconnected			1	----
07/21/2000-05:58:21	-	HSP2-1	Disconnected			1	----
07/21/2000-05:58:27	-	HSP2-1	Connected to	DSP1-6	1	----	
07/21/2000-06:02:38	-	HSP2-1	Disconnected			1	----
07/21/2000-06:02:38	-	DSP1-6	Disconnected			1	----
07/21/2000-06:02:43	-	HSP2-1	Connected to	DSP1-5	1	----	
07/21/2000-06:04:40	-	HSP2-1	Disconnected			1	----
07/21/2000-06:04:40	-	DSP1-5	Disconnected			1	----
07/21/2000-06:05:48	-	HSP2-1	Connected to	DSP1-1	1	----	
07/21/2000-06:05:58	-	DSP1-3	Connected to	DSP1-1	1	----	
07/21/2000-06:11:45	-	DSP1-3	Disconnected			1	----
07/21/2000-06:11:53	-	DSP1-1	Disconnected			1	----
07/21/2000-06:11:53	-	HSP2-1	Disconnected			1	----
07/21/2000-06:13:22	-	HSP2-1	Connected to	DSP1-5	1	----	
07/21/2000-06:14:56	-	DSP1-1	Connected to	HSP2-1	1	----	
07/21/2000-06:19:03	-	DSP1-6	Connected to	DSP1-5	1	----	

```
07/21/2000-06:27:19 - DSP1-1    Disconnected                      1       ----
07/21/2000-06:28:58 - DSP1-5    Disconnected                      1       ----
07/21/2000-06:28:59 - DSP1-6    Disconnected                      1       ----
07/21/2000-06:28:59 - HSP2-1    Disconnected                      1       ----
07/21/2000-06:39:15 - HSP2-1    Connected to    DSP1-5  1         ----
07/21/2000-06:40:26 - DSP1-2    Connected to    DSP1-5  1         ----
07/21/2000-06:42:58 - DSP1-5    Disconnected                      1       ----
07/21/2000-06:42:59 - DSP1-2    Disconnected                      1       ----
07/21/2000-06:42:59 - HSP2-1    Disconnected                      1       ----
07/21/2000-06:58:19 - HSP2-1    Connected to    DSP1-1  1         ----
07/21/2000-06:59:17 - DSP1-1    Disconnected                      1       ----
07/21/2000-06:59:17 - HSP2-1    Disconnected                      1       ----
07/21/2000-06:59:22 - HSP2-1    Connected to    DSP1-5  1         ----
07/21/2000-07:00:08 - DSP1-2    Connected to    DSP1-5  1         ----
07/21/2000-07:00:48 - DSP1-3    Connected to    DSP1-4  2         ----
07/21/2000-07:01:02 - DSP1-4    Disconnected                      2       ----
07/21/2000-07:01:02 - DSP1-3    Disconnected                      2       ----
07/21/2000-07:01:24 - DSP1-2    Disconnected                      1       ----
07/21/2000-07:01:25 - DSP1-5    Disconnected                      1       ----
07/21/2000-07:01:25 - HSP2-1    Disconnected                      1       ----
07/21/2000-07:03:53 - DSP1-1    Connected to    DSP1-3  1         ----
07/21/2000-07:04:35 - DSP1-1    Disconnected                      1       ----
07/21/2000-07:04:35 - DSP1-3    Disconnected                      1       ----
07/21/2000-07:05:20 - DSP1-1    Connected to    DSP1-2  1         ----
07/21/2000-07:08:00 - DSP1-1    Disconnected                      1       ----
07/21/2000-07:08:00 - DSP1-2    Disconnected                      1       ----
07/21/2000-07:25:56 - HSP2-1    Connected to    DSP1-1  1         ----
07/21/2000-07:27:31 - DSP1-1    Disconnected                      1       ----
07/21/2000-07:27:31 - HSP2-1    Disconnected                      1       ----
07/21/2000-07:27:43 - HSP2-1    Connected to    DSP1-5  1         ----
07/21/2000-07:27:56 - DSP1-2    Connected to    DSP1-5  1         ----
07/21/2000-07:29:13 - DSP1-2    Disconnected                      1       ----
07/21/2000-07:29:57 - DSP1-1    Connected to    DSP1-5  1         ----
07/21/2000-07:30:17 - DSP1-1    Disconnected                      1       ----
07/21/2000-07:30:28 - DSP1-1    Connected to    DSP1-5  1         ----
07/21/2000-07:30:41 - DSP1-1    Disconnected                      1       ----
07/21/2000-07:31:01 - DSP1-5    Disconnected                      1       ----
07/21/2000-07:31:01 - HSP2-1    Disconnected                      1       ----
```

Table 11: Annotated Log File Mappping to Specific Tests

Test	Date / Time	Connection	Comments
--	07/21/2000-05:09:37	HSP2-1 Connected to DSP1-6	
--	07/21/2000-05:17:39	DSP1-6 Disconnected	
--	07/21/2000-05:17:39	HSP2-1 Disconnected	
1	07/21/2000-05:23:07	HSP2-1 Connected to DSP1-1	HSP2-1 connected to APD radio 1 (800Mhz)
1	07/21/2000-05:24:17	DSP1-1 Disconnected	
1	07/21/2000-05:24:17	HSP2-1 Disconnected	
2	07/21/2000-05:25:00	HSP2-1 Connected to DSP1-3	HSP2-1 connected to MPD radio 3 (UHF)
2	07/21/2000-05:25:45	DSP1-3 Disconnected	
2	07/21/2000-05:25:45	HSP2-1 Disconnected	
2	07/21/2000-05:25:57	HSP2-1 Connected to DSP1-4	HSP2-1 connected to MPD radio 4 (UHF)
2	07/21/2000-05:27:05	DSP1-4 Disconnected	
2	07/21/2000-05:27:05	HSP2-1 Disconnected	
3	07/21/2000-05:27:15	HSP2-1 Connected to DSP1-6	HSP2-1 connected to Metro radio 6 (VHF)
3	07/21/2000-05:29:01	DSP1-6 Disconnected	
3	07/21/2000-05:29:01	HSP2-1 Disconnected	
4	07/21/2000-05:29:08	HSP2-1 Connected to DSP1-5	HSP2-1 connected to USPP radio 5 (VHF)
4	07/21/2000-05:31:30	HSP2-1 Disconnected	
4	07/21/2000-05:31:30	DSP1-5 Disconnected	
5	omitted	omitted	omitted
6	omitted	omitted	omitted
7	omitted	omitted	omitted
8	omitted	omitted	omitted
9	07/21/2000-05:34:14	DSP1-1 Connected to DSP1-3	APD radio 1 (800MHz) connected to MPD radio 3 (UHF)
9	07/21/2000-05:35:56	DSP1-1 Disconnected	
9	07/21/2000-05:35:56	DSP1-3 Disconnected	
10	07/21/2000-05:36:10	DSP1-1 Connected to DSP1-6	APD radio 1 (800MHz) connected to Metro radio 6 (VHF)
10	07/21/2000-05:38:01	HSP2-1 Connected to DSP1-1	HSP2-1 connected to APD radio 1 (800MHz)
10	07/21/2000-05:38:22	DSP1-6 Disconnected	
11	07/21/2000-05:38:52	DSP1-5 Connected to DSP1-1	USPP radio 5 (VHF) connected to APD radio 1 (800MHz)
11 & 12	07/21/2000-05:39:59	DSP1-5 Disconnected	HSP2-1 ***still*** connected to APD radio 1 (800MHz)
12	07/21/2000-05:41:57	DSP1-1 Disconnected	
12	07/21/2000-05:41:57	HSP2-1 Disconnected	
13	07/21/2000-05:42:07	HSP2-1 Connected to DSP1-3	HSP2-1 connected to MPD radio 3 (UHF)
13	07/21/2000-05:46:53	DSP1-3 Disconnected	
13	07/21/2000-05:46:53	HSP2-1 Disconnected	

Test	Date / Time	Connection	Comments
14 & 15	07/21/2000-05:47:08	HSP2-1 Connected to DSP1-5	HSP2-1 connected to Metro / USPP radio 5 (VHF)
15	07/21/2000-05:49:51	DSP1-5 Disconnected	
15	07/21/2000-05:49:51	HSP2-1 Disconnected	
16	07/21/2000-05:49:55	HSP2-1 Connected to DSP1-1	HSP2-1 connected to APD radio 1 (800MHz)
16	07/21/2000-05:51:42	DSP1-1 Disconnected	
16	07/21/2000-05:51:42	HSP2-1 Disconnected	
17	07/21/2000-05:51:50	HSP2-1 Connected to DSP1-3	HSP2-1 connected to MPD radio 3 (UHF)
17	07/21/2000-05:55:45	DSP1-3 Disconnected	
17	07/21/2000-05:55:45	HSP2-1 Disconnected	
18	07/21/2000-05:55:51	HSP2-1 Connected to DSP1-5	HSP2-1 connected to Metro radio 5 (VHF)
18	07/21/2000-05:58:21	DSP1-5 Disconnected	
18	07/21/2000-05:58:21	HSP2-1 Disconnected	
18 & 19	07/21/2000-05:58:27	HSP2-1 Connected to DSP1-6	HSP2-1 connected to Metro / USPP radio 6 (VHF)
19	07/21/2000-06:02:38	HSP2-1 Disconnected	
19	07/21/2000-06:02:38	DSP1-6 Disconnected	
19	07/21/2000-06:02:43	HSP2-1 Connected to DSP1-5	HSP2-1 connected to USPP radio 5 (VHF)
19	07/21/2000-06:04:40	HSP2-1 Disconnected	
19	07/21/2000-06:04:40	DSP1-5 Disconnected	
20	07/21/2000-06:05:48	HSP2-1 Connected to DSP1-1	HSP2-1 connected to APD radio 1 (800MHz)
20	07/21/2000-06:05:58	DSP1-3 Connected to DSP1-1	MPD radio 3 (UHF) connected to APD radio 1 (800MHz)
20	07/21/2000-06:11:45	DSP1-3 Disconnected	
20	07/21/2000-06:11:53	DSP1-1 Disconnected	
20	07/21/2000-06:11:53	HSP2-1 Disconnected	
21	07/21/2000-06:13:22	HSP2-1 Connected to DSP1-5	HSP2-1 connected to USPP radio 5 (VHF)
21	07/21/2000-06:14:56	DSP1-1 Connected to HSP2-1	APD radio 1 (800MHz) connected to HSP2-1
22	07/21/2000-06:19:03	DSP1-6 Connected to DSP1-5	Metro radio 6 (VHF) connected to USPP radio 5 (VHF)
22	07/21/2000-06:27:19	DSP1-1 Disconnected	
22	07/21/2000-06:28:58	DSP1-5 Disconnected	
22	07/21/2000-06:28:59	DSP1-6 Disconnected	
22	07/21/2000-06:28:59	HSP2-1 Disconnected	
23	omitted	omitted	omitted
--	07/21/2000-06:39:15	HSP2-1 Connected to DSP1-5	
--	07/21/2000-06:40:26	DSP1-2 Connected to DSP1-5	
--	07/21/2000-06:42:58	DSP1-5 Disconnected	
--	07/21/2000-06:42:59	DSP1-2 Disconnected	
--	07/21/2000-06:42:59	HSP2-1 Disconnected	
--	07/21/2000-06:58:19	HSP2-1 Connected to DSP1-1	

Test	Date / Time	Connection	Comments
--	07/21/2000-06:59:17	DSP1-1 Disconnected	
--	07/21/2000-06:59:17	HSP2-1 Disconnected	
--	07/21/2000-06:59:22	HSP2-1 Connected to DSP1-5	
--	07/21/2000-07:00:08	DSP1-2 Connected to DSP1-5	
--	07/21/2000-07:00:48	DSP1-3 Connected to DSP1-4	
--	07/21/2000-07:01:02	DSP1-4 Disconnected	
--	07/21/2000-07:01:02	DSP1-3 Disconnected	
--	07/21/2000-07:01:24	DSP1-2 Disconnected	
--	07/21/2000-07:01:25	DSP1-5 Disconnected	
--	07/21/2000-07:01:25	HSP2-1 Disconnected	
--	07/21/2000-07:03:53	DSP1-1 Connected to DSP1-3	
--	07/21/2000-07:04:35	DSP1-1 Disconnected	
--	07/21/2000-07:04:35	DSP1-3 Disconnected	
--	07/21/2000-07:05:20	DSP1-1 Connected to DSP1-2	
--	07/21/2000-07:08:00	DSP1-1 Disconnected	
--	07/21/2000-07:08:00	DSP1-2 Disconnected	
--	07/21/2000-07:25:56	HSP2-1 Connected to DSP1-1	
--	07/21/2000-07:27:31	DSP1-1 Disconnected	
--	07/21/2000-07:27:31	HSP2-1 Disconnected	
--	07/21/2000-07:27:43	HSP2-1 Connected to DSP1-5	
--	07/21/2000-07:27:56	DSP1-2 Connected to DSP1-5	
--	07/21/2000-07:29:13	DSP1-2 Disconnected	
--	07/21/2000-07:29:57	DSP1-1 Connected to DSP1-5	
--	07/21/2000-07:30:17	DSP1-1 Disconnected	
--	07/21/2000-07:30:28	DSP1-1 Connected to DSP1-5	
--	07/21/2000-07:30:41	DSP1-1 Disconnected	
--	07/21/2000-07:31:01	DSP1-5 Disconnected	
--	07/21/2000-07:31:01	HSP2-1 Disconnected	