PUBLIC SAFETY PSWN PROGRAM WIRELESS NETWORK

Saving Lives and Property Through Improved Interoperability

South Florida Pilot Implementation

Interconnection of Incompatible Radio Systems Via Console-to-Console Links and Mobile Audio Switches

A Combined Solution for Public Safety Wireless Interoperability

Final

October 2001

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EXECUTIVE SUMMARY

This report provides a detailed description of two approaches developed to meet interoperability requirements among public safety agencies in the south Florida area. The basic premise of this interoperability requirement assumes a mass migration scenario during which local, state, and federal agencies would have a need for interoperable communications. The agencies included in this particular interoperability pilot project were Florida Highway Patrol (FHP), Florida Department of Law Enforcement (FDLE), Broward County Sheriff's Office, Miami-Dade Police Department, Monroe County Sheriff's Office, U.S. Coast Guard (USCG), Federal Bureau of Investigation (FBI), Immigration and Naturalization Service (INS), and Border Patrol. The south Florida area provided a unique venue to develop a solution that would allow these agencies to communicate directly with each other, in a mass migration scenario, by using their own mobile and portable radios. The south Florida area uses not only land-based radio systems, but its proximity to the ocean also brings maritime communications systems into play. The variety of communications systems used in the south Florida public safety community presented an excellent opportunity for the Public Safety Wireless Network (PSWN) Program to develop a greatly needed interoperability solution.

Because of its proximity to the island of Cuba, south Florida may be at risk from a mass migration incident. Such an incident would require highly coordinated radio communications between all responding agencies. Because the responding agencies have a variety of incompatible radio systems, it is typically not possible for them to communicate directly using their own mobile and portable radio units. These agencies have land mobile radio (LMR) systems on the very high frequency (VHF) band, the ultra high frequency (UHF) band, and the 800 megahertz (MHz) frequency band. Agencies in the same frequency band that have conventional, non-trunked radio systems can have direct interoperability if they share frequencies and squelch codes. Agencies in the same frequency band that have compatible trunked radio systems can share talk groups for interoperability. Agencies using radio systems with incompatible, proprietary trunking protocols, such as those offered by Motorola and M/A-Com Private Radio Systems (formerly ComNet Ericsson), cannot share talk groups and must find another method to achieve interoperability. Agencies that do not conduct operations in the same frequency band cannot share frequencies to achieve interoperability and must also find another method to achieve interoperability. The agencies participating in this pilot operate in the UHF, VHF high, and 800 MHz frequency bands, and they also use incompatible trunked radio systems.

Several possible solutions were considered to provide the needed interoperability among the south Florida agencies. Further study of the agencies revealed that each has a console electronics switch it uses to control the base station radios in its respective LMR communications system. To provide an interoperability link to connect agencies with disparate radio systems, a console-to-console link was recommended. This link typically uses a leased four-wire telephone circuit to connect the desired consoles. The console electronics switches are linked together via the leased telephone circuit and treat each other as though they were connected to conventional base stations. A standard base interface module (BIM) (Motorola) or conventional interface card (CIC) (M/A-Com) is used to interface with the interconnecting four-wire telephone circuit. The consoles are typically set for voice operated transmit (VOX) operation, and voice audio supplied by one of the consoles to the telephone circuit will activate the corresponding console at the

other end of the circuit. This configuration creates a "patch" between the two consoles that can be used to connect users on one system together with users on the other system, thereby allowing field-unit-to-field-unit interoperability.

Although the console-to-console interoperability solution works very well, its usefulness is limited to the overlapping coverage areas of the LMR systems that are patched together. If agency-to-agency interoperability is needed in an area where one or both of the agency's LMR systems does not provide adequate radio coverage, the console-to-console solution will not provide the needed interoperability. This scenario was examined, and a separate solution was developed to provide the needed interoperability for the responding agencies. The PSWN Program provided mobile audio switches that could be used to link subscriber portable or mobile radio units together. Each mobile switch can interface with up to 12 different portable and mobile radio units and patch them together to provide interoperability between the various agencies. The PSWN Program provided one mobile audio switch and a corresponding VHF conventional mobile radio unit to each of the three selected counties in south Florida: Broward, Miami-Dade, and Monroe. The Integrated Program Team (IPT) decided that the three counties should own, manage, and maintain the audio switches to ensure that they were operational and available whenever they were needed. The IPT also decided which agencies and radio types would need to interface with the audio switches. Once that list was compiled, the PSWN Program ordered the appropriate interface cables for each audio switch. It was envisioned that each agency would supply the appropriate mobile and/or portable radio unit(s) to be connected to the audio switch at the scene of an incident.

This document provides the basic, essential information needed to understand how the south Florida pilot interoperability solutions were implemented, and consequently, offers a resource for all public safety agencies interested in such solutions. More information on these solutions, and on other means for achieving interoperability, is available from the PSWN Program, which sponsored and funded the development of the south Florida pilot interoperability concept. The PSWN Program can be contacted by e-mail at information@pswn.gov or by telephone at 1-800-565-PSWN. The program's Web site, at www.pswn.gov, provides a wealth of information regarding public safety wireless interoperability.

1. INTRODUCTION

The Public Safety Wireless Network (PSWN) Program works with public safety agencies nationwide to help achieve interoperability—seamless, coordinated, integrated public safety wireless communications that promote safe, efficient protection of life and property. The PSWN Program works with the public safety community to improve the interoperability of wireless communications by promoting coordination and partnerships, seeking funding alternatives, advocating adequate public safety spectrum allocations and efficient spectrum use, supporting technical standards development, and fostering secure communications.

The development and implementation, for proof-of-concept purposes, of technical solutions for interoperability among public safety networks is one of the PSWN Program's main areas of activity. These solutions, which are initiated as pilot projects in various regions throughout the country, are developed jointly by the PSWN Program Management Office (PMO) and public safety radio and operational personnel from the region. The individuals involved most directly in pilot development and operation constitute the pilot's Integrated Program Team, or IPT. IPT members focus the pilot effort and technical concept to be proven into a discrete, repeatable solution for an interoperability shortfall common among public safety agencies throughout the Nation. This approach allows the PSWN PMO to leverage the solution beyond the pilot region, and more broadly, to benefit the public safety community as a whole.

The PSWN Program sponsored a South Florida IPT for almost 2 years. The potential for a mass migration incident in the south Florida area encouraged the PSWN Program to look into the interoperability requirements of the various agencies that would respond to such an incident. The agencies that would be directly involved in the mass migration incident were contacted and an IPT was formed. The IPT first supported an assessment of interoperability needs in the south Florida area. The IPT then focused on pilot proof-of-concept activities targeting a specific interoperability shortfall, namely, the need for an interoperability solution between several disparate trunked and conventional radio systems to support certain public safety response situations. In response, the PSWN Program and its South Florida IPT developed a combined interoperability solution consisting of the Leased Circuit Interconnection of Dispatch Consoles (LCIDC), and three Mobile Audio Switching System (MASS) packages to provide mobile, on-site interoperability to all agencies working at an incident location. The LCIDC was designed to provide interoperability primarily between the Border Patrol Dispatch Center, Immigration and Naturalization Service (INS), Federal Bureau of Investigation (FBI), U.S. Coast Guard (USCG), Florida Department of Law Enforcement (FDLE), Florida Highway Patrol (FHP), Monroe County, Miami-Dade County, and Broward County by patching disparate land mobile radio (LMR) system infrastructure together through their respective console electronics switches. The Border Patrol Dispatch Center, which dispatches for INS, was selected as the hub of the LCIDC interoperability solution. All console-to-console patches are connected through the Border Patrol dispatchers. The MASS solutions were supplied to provide mobile, on-site solutions to patch disparate radio subscriber units together as well as disparate LMR system infrastructures.

Features of the LCIDC include—

- Dispatcher control and monitoring of all patching activity

- Capability of patching disparate trunked and conventional radio systems

- A "second level" of patching capabilities for all other agencies connected to the console electronics of the seven primary agencies

- Enhanced local, state, and federal interoperability during emergency situations and special events.

Features of the MASS include—

- Portability that allows the interoperability solution to be carried to the scene of an incident

- Field programmability to allow connection to virtually any agency's portable or mobile radio unit as it arrives at the scene of an incident

- Capability to link disparate trunked and conventional radio systems if the MASS is within the coverage areas of the desired radio systems

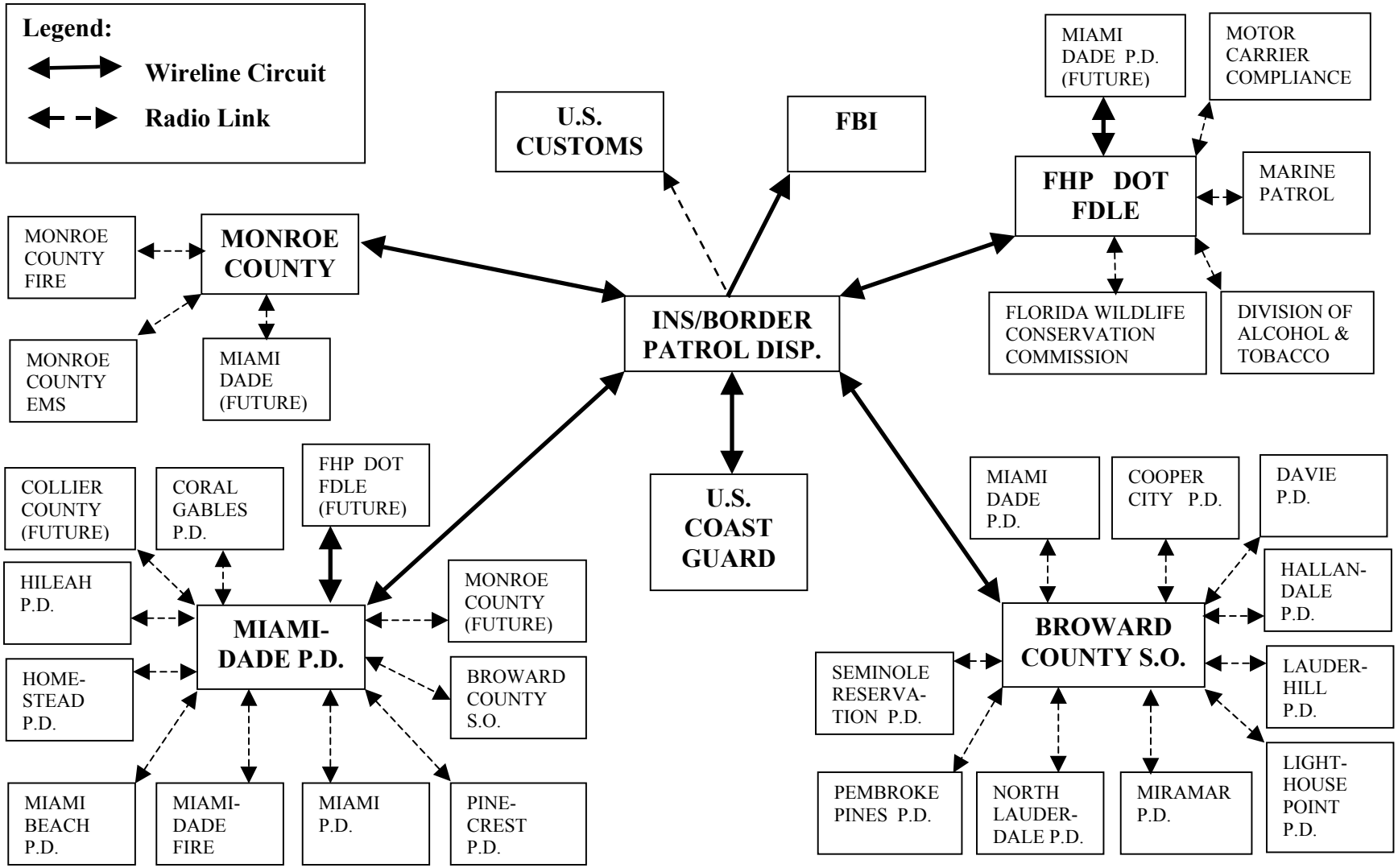
- Highly versatile patching capabilities, including portable radios, mobile radios, dial-up telephone circuits, and cellular telephones

- Enhanced local, state, and federal interoperability during emergency situations and special events.

The LCIDC consists of several components. These components work together to provide dispatcher control of console-to-console patches enabling public safety users of disparate trunked and conventional radio systems to communicate directly with each other. For example, Miami-Dade County has an M/A-Com trunked radio system, and FHP has a Motorola trunked radio system. Both agencies are connected to the Border Patrol dispatch console in Pembroke Pines via leased four-wire circuits. The Border Patrol dispatcher can create a patch between the consoles of these two agencies that would allow a Miami-Dade County unit on an M/A-Com talk group to talk directly to a FHP unit on a Motorola talk group. Once the patch is set between these two agencies, the dispatcher at either location can also select any conventional radio system connected to that dispatcher's respective console electronics switch. This configuration would allow patching of not only trunked talk groups but also trunked talk group(s) to conventional channel(s), as well as conventional channel(s) to conventional channel(s). The LCIDC is a very powerful interoperability solution in that it offers the flexibility to local, state, and federal agencies to communicate with each other using their own radios during major events requiring public safety interoperability.

As illustrated in Figure 1, the components used in the LCIDC include a base interface module (BIM) or conventional interface card (CIC) for each console electronics switch and a dedicated, leased four-wire circuit between the Border Patrol console electronics switch and the console electronics switches of the other six agencies. This solution uses commercial off-the-shelf (COTS) equipment and can readily be replicated in other regions where disparate radio systems need to be linked for radio interoperability.

Figure 1
Leased Circuit Interconnection of Dispatch Consoles
Configuration Diagram



The configuration diagram in Figure 1 depicts the seven participating agencies as well as other agencies that are connected to the console electronics of the participating agencies. The console electronics switch at Border Patrol is the "hub" of the LCIDC interoperability solution. All LCIDC patches must be initiated between the requesting agency's dispatcher and the Border Patrol dispatcher. An example of how the LCIDC would be initiated by two different agencies is outlined below. The numbered steps below are shown in Figure 2 to indicate the sequence of events as two different agencies' radio subscribers request separate LCIDC patches.

Border Patrol Initiates an LCIDC to Miami-Dade Police Department (PD)—See Figure 2

1-A: An INS subscriber unit calls the Border Patrol Dispatcher to request a patch to a Miami-Dade PD subscriber unit.

2-A: The Border Patrol Dispatcher contacts the Miami-Dade Dispatcher via the console intercom feature, an 800 megahertz (MHz) mutual-aid channel, or plain old telephone service (POTS), and indicates that an INS unit wants to speak to a Miami-Dade PD unit. The Miami-Dade dispatcher responds that the patch is set up and advises that the desired Miami-Dade PD unit will be contacted.

3-A: The Miami-Dade PD unit is notified and instructed to call the appropriate INS unit on the patch. The dispatchers monitor the patch long enough to ensure that it is performing satisfactorily. The Miami-Dade PD unit and the INS unit conduct business over the patched systems. When their business is completed, the subscriber units notify their respective dispatchers so that the patch can be removed. The patch is removed and the systems are returned to normal configuration.

USCG Initiates an LCIDC to FHP—See Figure 2

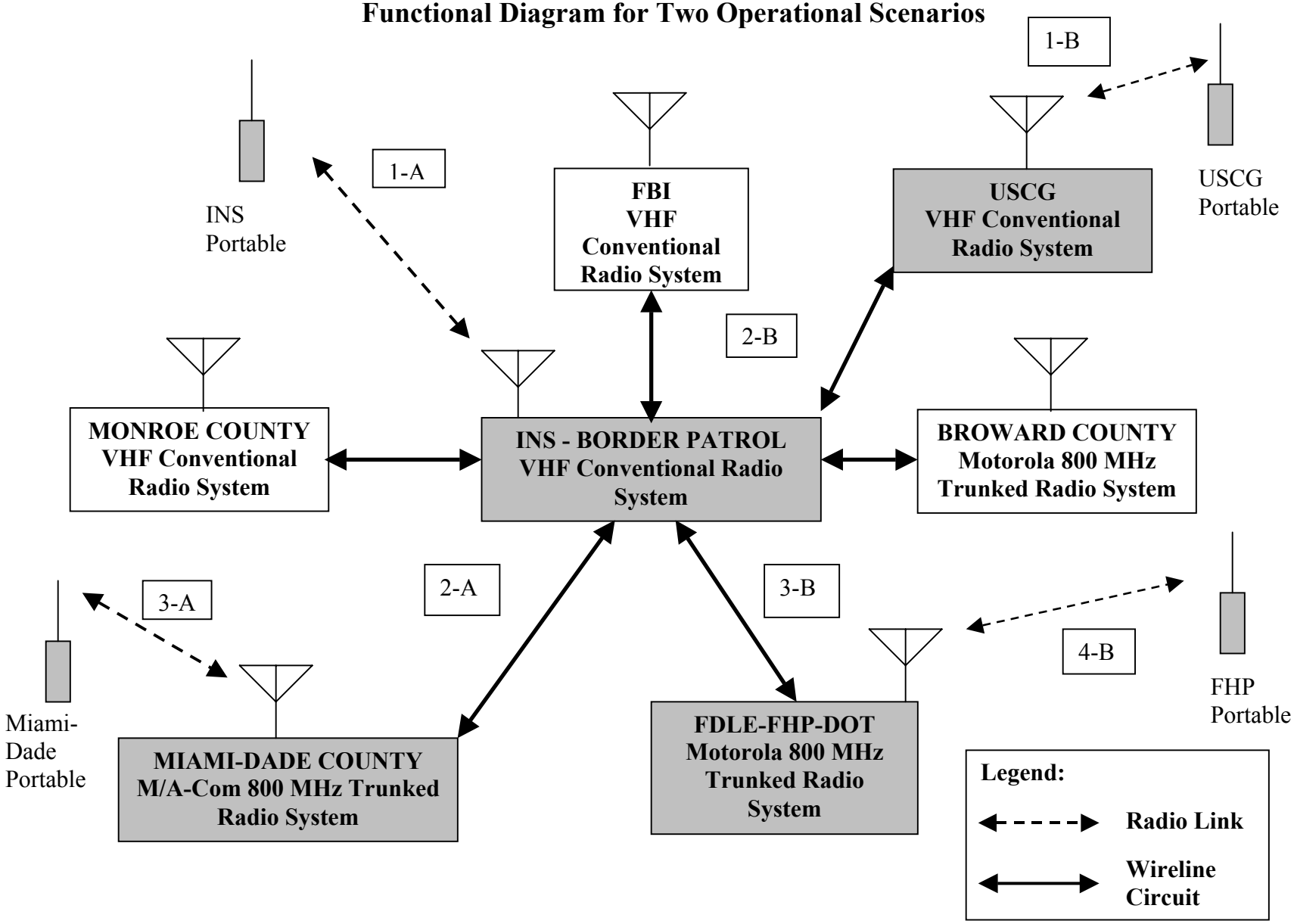
1-B: A USCG subscriber unit calls the USCG dispatcher to request a patch to an FHP subscriber unit.

2-B: The USCG dispatcher contacts the Border Patrol Dispatcher via the console intercom feature, an 800 MHz mutual-aid channel, or POTS, and indicates that a USCG unit wants to speak to a FHP unit. The Border Patrol dispatcher responds and advises USCG that the FHP dispatcher will be contacted to set up the required patch.

3-B: The Border Patrol dispatcher contacts the FHP dispatcher and indicates that USCG desires to patch a USCG subscriber unit to a FHP subscriber unit. The Border Patrol dispatcher verifies with both USCG and FHP that a completed patch is working and available.

4-B: The FHP dispatcher notifies the appropriate subscriber unit that a patch is completed to the requesting USCG subscriber unit and advises the FHP dispatcher to call the requesting unit. The respective dispatcher monitor the patch long enough to ensure that it is performing satisfactorily. The USCG unit and the FHP unit conduct business over the patched systems. When their business is completed, the subscriber units notify their respective dispatchers so that the patches can be removed. The patches are removed and the systems are returned to normal configuration.

Figure 2
Leased Circuit Interconnection of Dispatch Consoles
Functional Diagram for Two Operational Scenarios



The MASS consists of a COTS audio switch manufactured by JPS Communications, Inc. It is a model ACU-1000 switch that was ordered equipped with a full complement of 12 interface cards. A total of three ACU-1000 audio switches were supplied by the PSWN Program to three southern counties in Florida: Broward, Dade, and Monroe. Further study revealed the most likely radio types that would be interfaced to the ACU-1000 switches, and the appropriate cables were ordered for each radio type. The IPT decided that the three counties should be the caretakers of the ACU-1000 audio switches. They would maintain and deploy the switches as necessary. These audio switches have the ability to interface with, and patch to, a variety of portable and mobile LMR subscriber units, standard POTS lines, or cellular telephones. JPS Communications, Inc., manufactures a variety of mobile and portable radio interface cables to allow direct connection between the subscriber units and the audio switch. Each of the three audio switches were ordered with a full complement of cards to allow interfacing of up to 10 LMR subscriber units and 2 POTS lines. Each switch was also equipped with the local speaker and computer interface to allow local on-site programming in the field as the requirements for interoperability change with the dynamics of an incident.

Although the ACU-1000 is described as a mobile audio switch in this report, the audio switch may also be permanently mounted in a fixed location if the interoperability needs of the participating agencies should warrant it. However, it is the mobility and programming "on the fly" that makes the ACU-1000 so valuable. Command vehicles and emergency communications vans are often ideal environments for the ACU-1000 audio switch.

Figure 3 depicts an operational scenario for which the MASS is very well suited. This configuration will allow radios that operate in different frequency bands to interoperate. The Miami-Dade 800 MHz trunked radio switches to an 800 MHz conventional mutual-aid channel to allow it to talk directly to the 800 MHz portable attached to the ACU-1000 audio switch. The USCG conventional radio use a direct frequency that does not access a repeater to allow it to talk directly to the USCG very high frequency (VHF) radio attached to the ACU-1000 audio switch. The numbered steps below are shown in the figure to indicate the sequence of events as the two different agencies communicate directly through the MASS. This scenario will work only if the ACU-1000 has been programmed for the particular make and model of subscriber units that will be attached to it.

MASS–Miami-Dade 800 MHz to USCG VHF—See Figure 3

1-A: Miami-Dade radio user selects a conventional 800 MHz mutual-aid channel that is also programmed into the Miami-Dade radio unit attached to the ACU-1000 audio switch. This is a simplex channel that does not access a repeater system. The Miami-Dade radio user presses the push-to-talk (PTT) button and calls the USCG radio user with whom communications are required.

2-A: The Miami-Dade radio unit attached to the ACU-1000 audio switch receives the signal and sends control information and received audio to the ACU-1000 audio switch.

3-A: The ACU-1000 audio switch, per its internal programming, selects the desired attached radio unit and sends a PTT signal plus transmit audio to the USCG VHF portable radio unit.

4-A: Upon receiving the PTT signal and transmit audio from the ACU-1000 audio switch, the attached USCG portable radio unit sends the information to the USCG radio user in the field. When the USCG radio user in the field receives the call, he or she pushes the PTT button and starts the above process in the reverse direction to communicate with the Miami-Dade radio user who initiated the call.

MASS–Miami-Dade 800 MHz-to-Broward County 800 MHz—See Figure 4

1-B: The Miami-Dade radio user selects a trunked 800 MHz talk group that is also programmed into the Miami-Dade trunked radio unit attached to the ACU-1000 audio switch. This is a trunked talk group that accesses a trunked 800 MHz M/A-Com repeater system. The Miami-Dade radio user presses the PTT button and calls the Broward County radio user with whom communications are desired.

2-B: The signal from the Miami-Dade trunked field radio unit is assigned a channel on the M/A-Com 800 MHz trunked radio system. The Miami-Dade trunked radio attached to the ACU-1000 audio switch is assigned to the same channel.

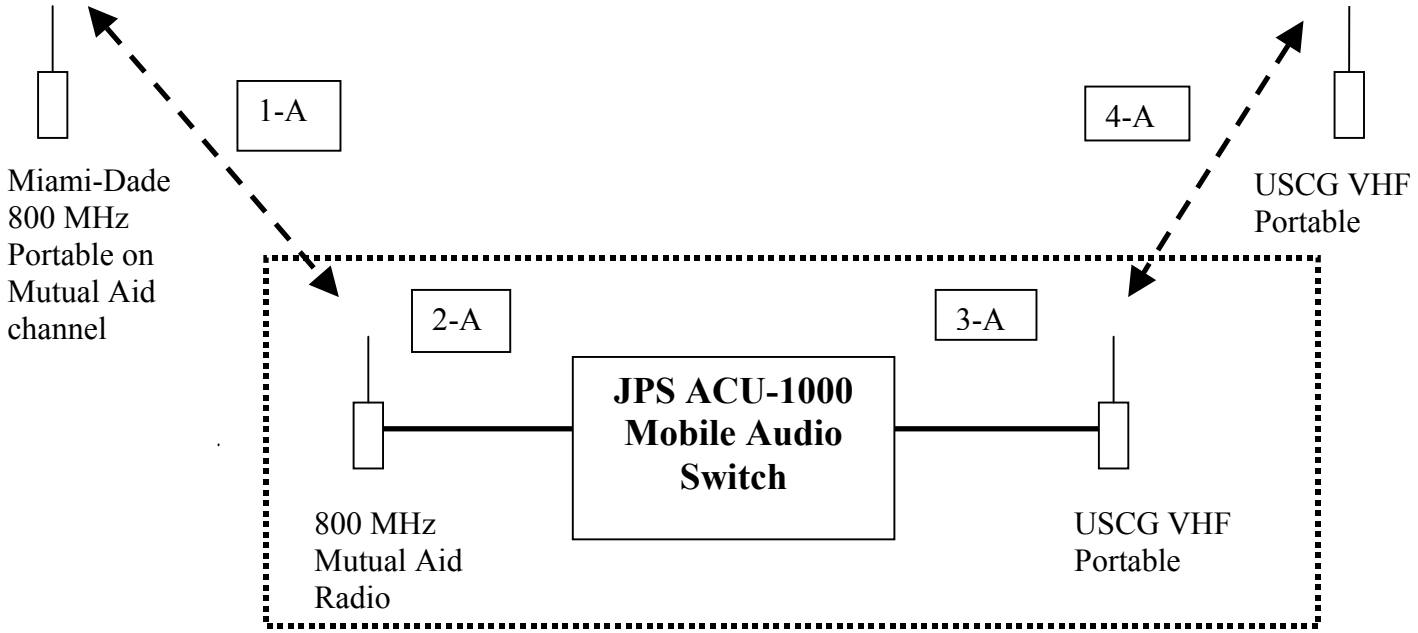
3-B: The signal from the Miami-Dade field radio unit is received by the Miami-Dade radio unit attached to the ACU-1000, and it sends control information and received audio to the ACU-1000 audio switch.

4-B: The ACU-1000 audio switch, per its internal programming, selects the attached Broward County Motorola 800 MHz trunked radio unit, and sends a PTT signal plus transmit audio to it.

5-B: Upon receiving the PTT signal and transmit audio from the ACU-1000 audio switch, the attached Broward County trunked radio unit transmits a channel request to the Motorola 800 MHz trunked radio system.

6-B: The attached radio unit and the Broward County field radio unit are assigned to the same channel, and the message from the Miami-Dade field radio unit is received by the Broward County field radio unit. When the Broward County radio user in the field receives the call, he or she pushes the PTT button and starts the above process in the reverse direction to communicate with the Miami-Dade radio user who initiated the call.

Figure 3
JPS ACU-1000 Mobile Audio Switch
Operational Scenario: Conventional 800 MHz-to-Conventional VHF

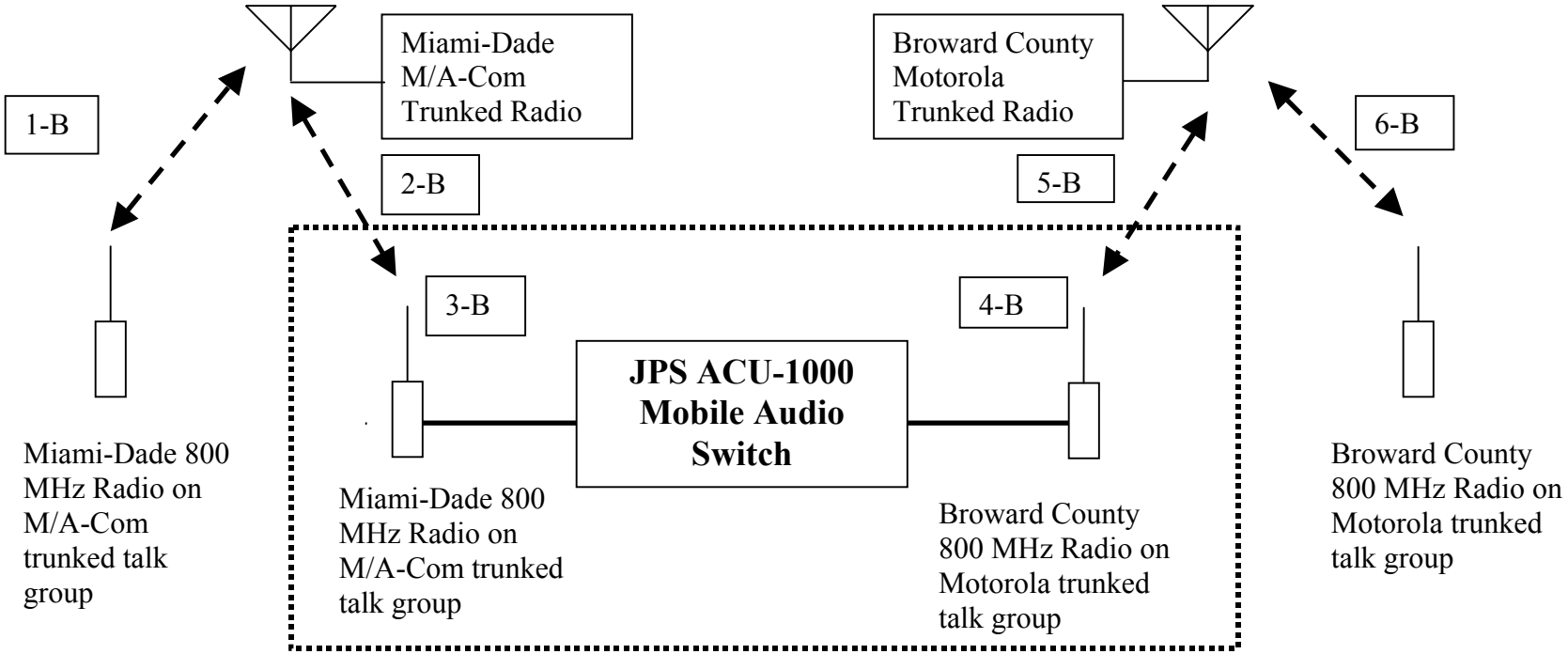


Mobile Audio Switch Solution

NOTE: The Mobile Audio Switching Solution can be parked at the scene of an incident to provide local on-site interoperability coverage

Legend:
Radio Link
Wireline Circuit

Figure 4
JPS ACU-1000 Mobile Audio Switch
Operational Scenario: M/A-Com 800 MHz Trunked System Linked to Motorola 800 MHz Trunked System



Mobile Audio Switch Solution

NOTE: The Mobile Audio Switch Solution can be parked at the scene of an incident to provide local on-site interoperability coverage

Legend:

Radio Link

Wireline Circuit

2. SYSTEM COMPONENTS

The balance of this report describes the LCIDC and MASS in greater detail. The report is based on the implementation and initial operation of the LCIDC and MASS in the south Florida area. Accordingly, the details of the LCIDC and MASS configurations relate to specific requirements of those areas. With that caveat, the remainder of this report was written in as general a manner as possible to make it useful to all public safety agencies with a need for this type of interoperability solution.

The LCIDC and MASS designs integrate several COTS components into a public safety wireless interoperability solution appropriate for certain situations. By adding equipment to the console electronics switches at the selected participating agencies and providing four-wire leased telephone circuits between those console switches, the South Florida IPT has created the LCIDC. This solution is extremely versatile, and it works very well in areas with overlapping radio system coverage. Dispatchers create talk group-to-talk group patches between the participating agencies by linking the appropriate icons on their respective consoles. The connectivity between each participating agency and Border Patrol is provided by leased four-wire telephone circuits. In addition, Miami-Dade County has several "outside agency" base stations "linked" to its console electronics switch, as shown in Figure 1, that allow its dispatchers to create console patches among trunked talk groups, trunked system subscribers, and conventional subscriber units.

For areas that do not have the desired overlapping radio system coverage, the MASS was developed to provide on-site interoperability and connectivity between disparate conventional and trunked radio system users. This connectivity can be established directly from subscriber unit to subscriber unit through the ACU-1000 audio switch, without accessing any radio system infrastructure. It can also be established through the radio system infrastructures with the system-to-system link provided by an ACU-1000 audio switch interfaced directly to the proper subscriber radio units.

The following subsections describe the LCIDC and MASS components in more detail.

2.1 System Components of the LCIDC Interoperability Solution

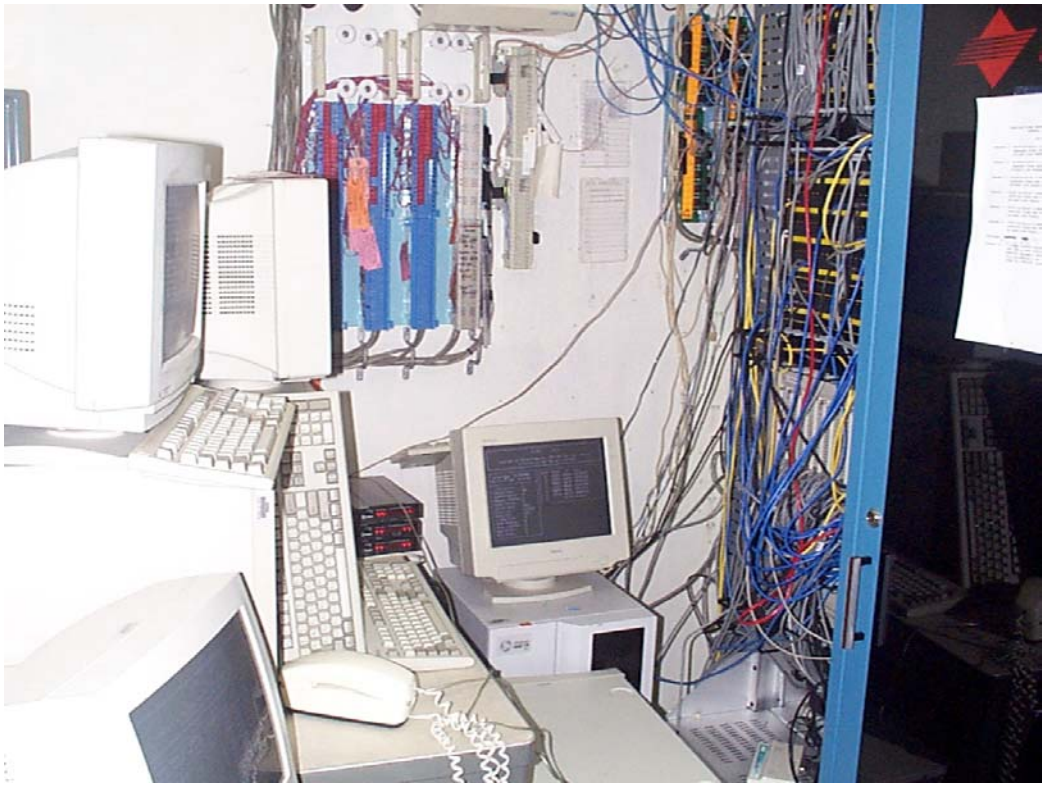
The LCIDC design is made up of several COTS components. The dispatch console electronics switches at each location must interface to one or more leased four-wire telephone circuits. The proper method of connecting to these circuits is through a conventional interface board or card that can match the impedance of the telephone circuit, use the proper input and output levels, and provide signaling to activate the console at the far end of the telephone circuit. To make the connection in some cases, it was simply a matter of connecting the four-wire circuit to an existing conventional interface board. In other cases, a conventional interface board was not available in the console electronics switch, and a board was procured for the solution. In the case of the Border Patrol dispatch center at the Border Patrol facility in Pembroke Pines, the existing console electronics bank (CEB) was working at capacity. The Border Patrol console, however, was designated by the IPT to be the "hub" of the console-to-console interoperability solution because, prior to the start of the South Florida Pilot Project, INS had planned to install

leased circuits from Pembroke Pines to both FDLE and Monroe County. To interface with the additional circuits identified by the IPT, the Border Patrol CEB would have to interface with a minimum of five new four-wire leased circuits. It was determined that an upgrade to the Motorola "Embassy™" configuration would be necessary. This upgrade was the most complex and costly part of the South Florida Interoperability Pilot Project implementation.

2.1.1 Motorola CEB at Border Patrol

The Border Patrol dispatch location was chosen by the IPT to be the central switching point for the LCIDC interoperability design. The Motorola CEB located there, shown in Figure 5, was operating at near capacity, and was not capable of handling the five additional four-wire leased telephone circuits required to link the designated agencies to the Border Patrol location. To ensure the proper equipment was ordered, the technical group at INS headquarters was consulted. After determining the circuit interface requirements, the INS technical group was able to provide the IPT with the list of equipment necessary to upgrade the CEB for the intended interoperability solution. The list of equipment included upgrading the existing console to an Embassy™ configuration to allow a sufficient quantity of card cage slots that would accommodate the five additional BIMs necessary to interface with the new four-wire telephone circuits. The equipment was ordered and shipped to the Border Patrol dispatch location in Pembroke Pines, Florida, where it was inventoried to verify that all equipment ordered was delivered and had arrived in good condition.

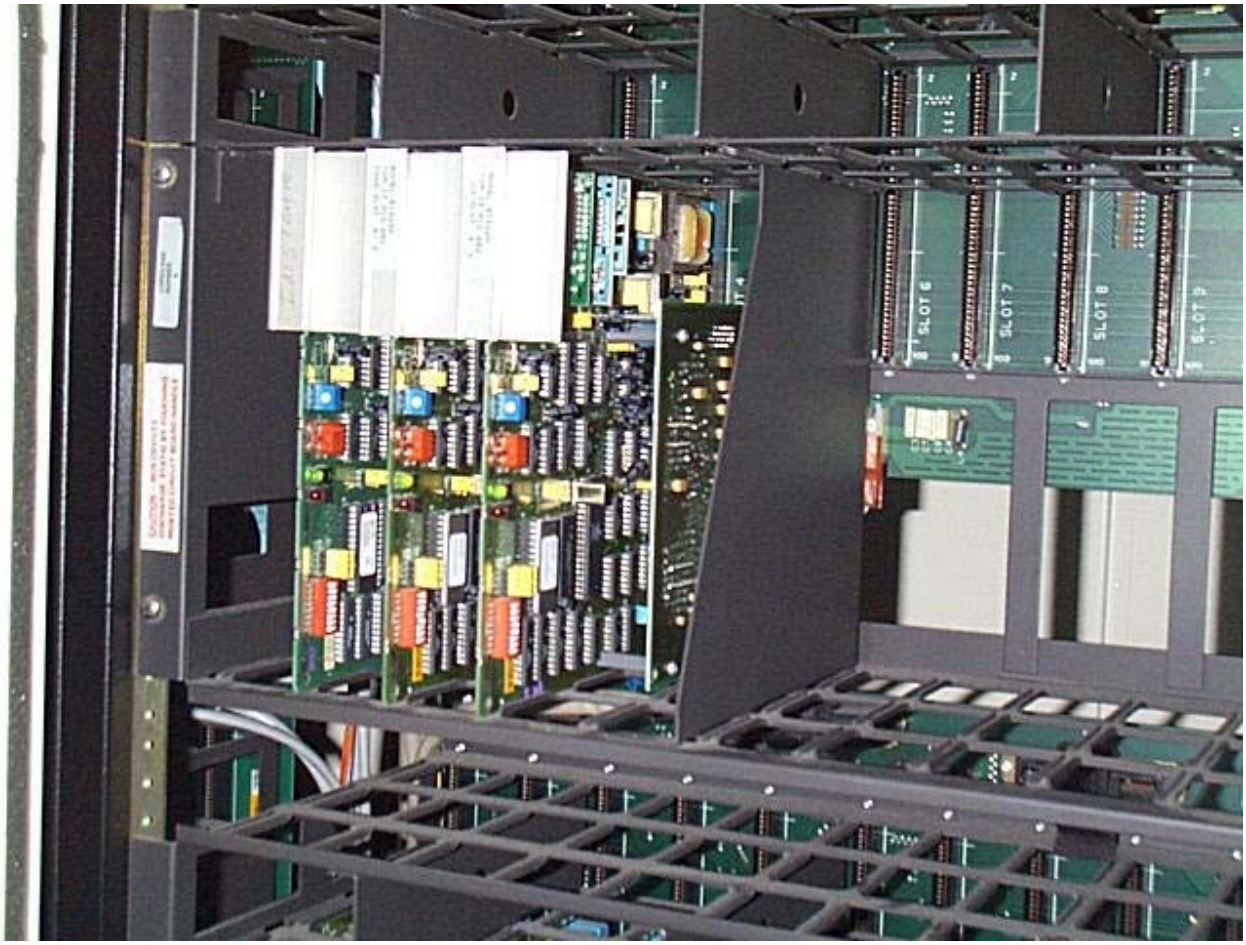
Figure 5
Border Patrol CEB Room



2.1.2 Motorola Console CEB at USCG

The USCG dispatch location in Miami, Florida, was one of the five locations chosen by the IPT to be connected to the Border Patrol console in Pembroke Pines, Florida. The USCG IPT representative indicated the CEB, shown in Figure 6, was capable of accommodating the additional four-wire telephone circuit with the addition of a BIM card and reprogramming of the CEB and dispatch consoles.

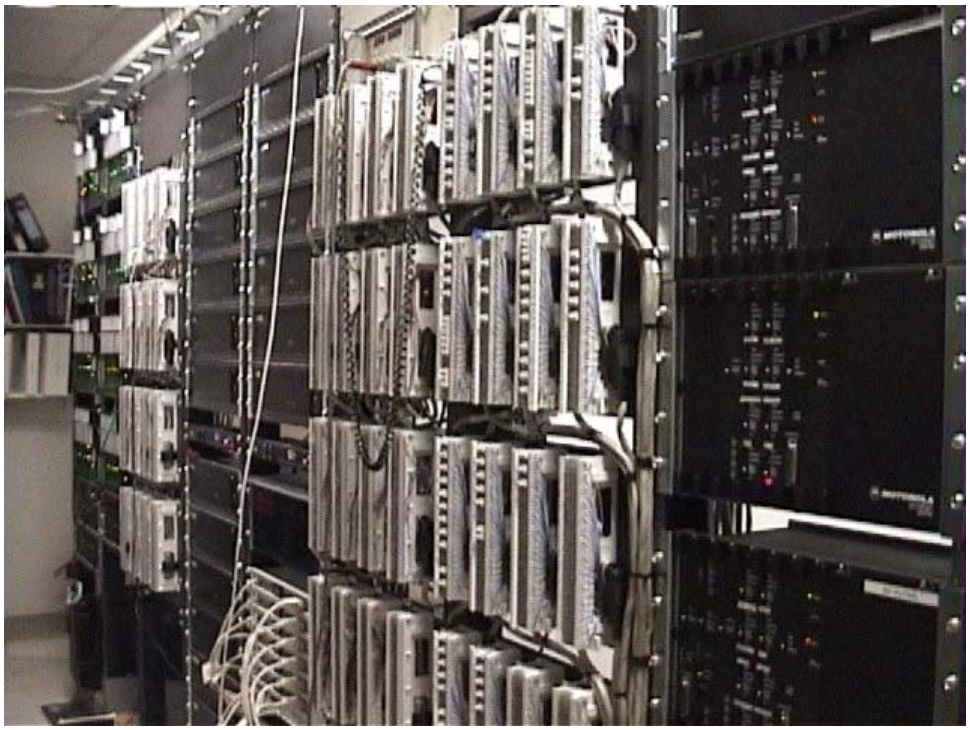
Figure 6
USCG CEB Room



2.1.3 Motorola Console CEB at FBI

The FBI dispatch location in Miami, Florida, was another of the five locations chosen by the IPT to be connected to the Border Patrol console in Pembroke Pines, Florida. The FBI CEB, shown in Figure 7, was capable of accommodating the additional four-wire telephone circuit with no additional components required. The FBI technical staff on site accomplished the required installation and reprogramming procedures.

Figure 7
FBI CEB Room



2.1.4 M/A-Com CES at Miami-Dade PD

To connect the new four-wire leased telephone circuit to the console electronics switch (CES) at Miami-Dade PD., shown in Figure 8, it was necessary to add more equipment. The technical supervisor at Miami-Dade PD determined what equipment was needed and provided the list to the IPT. The equipment was ordered, and when it arrived on site, it was inventoried to ensure all the equipment had arrived in good condition. The original order was complete except for a "VMIM to CCI Data Cable" because the M/A-Com sales team could verify neither the description of the part, nor the proper part number. The Miami-Dade technical supervisor and the M/A-Com sales team eventually resolved this problem.

Figure 8
Miami-Dade PD CES Room

2.1.5 Motorola CEB at Broward County SO

Discussion with the Broward County Sheriff's Office (SO) technician revealed that he preferred not to have a new four-wire leased telephone circuit installed at the Broward County SO CEB, shown in Figure 9. Instead, he recommended that a radio frequency (RF) link be established between the Broward County SO dispatch location and the Border Patrol dispatch location. The Broward County SO technician provided a recommended equipment list, and the IPT ordered the equipment. After it arrived, the equipment was inventoried to ensure all of the equipment had arrived and was in good condition.

The desktop trunked radio was ordered to provide two functions when it was installed. It would provide access to an 800 MHz mutual-aid channel to allow other agencies to call in to request an LCIDC patch. It would also provide a wireless link into the Broward County SO 800 MHz trunked radio system, to complete an LCIDC patch when requested.

The Border Patrol dispatch console could not remotely switch the desktop radio between the mutual-aid conventional mode and the Broward County SO trunked system mode.

Figure 9
Broward County SO CEB Room

Therefore, the IPT decided to install a leased telephone circuit between the Border Patrol Dispatch location and the Broward County SO location. The desktop radio was left on the mutual-aid channel, and the LCIDC patch was to be implemented over the new leased telephone circuit.

2.1.6 Motorola CEB at Monroe County SO

The Monroe County SO dispatch location in Marathon, Florida, was another of the five locations chosen by the IPT to be connected to the Border Patrol console in Pembroke Pines, Florida. The

Monroe County SO CEB was capable of accommodating the additional four-wire telephone circuit without ordering any additional equipment. No digital pictures of the Monroe County SO CEB were available for this report.

2.1.7 Motorola CEB at FDLE/FHP

The four-wire leased telephone circuit between FDLE and the Border Patrol dispatcher at Pembroke Pines was installed as a joint effort between FDLE and INS. This circuit was functioning at the beginning of the South Florida Pilot Project, thus the interoperability link was in place and operational prior to the start of the pilot project. Testing of the LCIDC patch between Border Patrol and FHP revealed that a FHP unit patched through the LCIDC interoperability patch could not "hear" the mobile radio unit with which it was trying to communicate. This problem was resolved when the FDLE technician reprogrammed the console electronics bank to accommodate the new BIM card interface to the leased circuit that provides the console-to-console link to Border Patrol. The FDLE CEB room is shown in Figure 10.

Figure 10
FDLE/FHP CEB Room

2.1.8 Leased Telephone Circuits

Table 1 below lists the data for the five leased four-wire telephone circuits used for the console-to-console interoperability solution, as proposed by the South Florida IPT.

Table 1: Leased Circuits for South Florida

CIRCUIT ID:	LOCATION:	ORDER NUMBER:	COMPLETION DATE:
80.PLNC.502921..SB	FBI	NR81Y7W5	10/10/2000
80.PLNC.502922..SB	MONROE COUNTY	NR55G4P4	09/19/2000
80.PLNC.502923..SB	DADE COUNTY	NR7LBR56	09/19/2000
80.PLNC.502924..SB	US COAST GUARD	NRFB6552	09/19/2000
80.PLNC.501398..SB	BROWARD COUNTY	NR74GR47	03/06/2001

2.2 System Components of the MASS Interoperability Solution

To supplement the performance of the LCIDC interoperability solution, a MASS was recommended by the IPT. The LCIDC interoperability solution works very well where the linked radio system infrastructures provide overlapping coverage. However, if interoperability is needed in an area where the system infrastructures of the participating agencies do not provide overlapping radio coverage, the usefulness of the LCIDC solution is diminished. The MASS is designed to be a portable interoperability solution that can provide agency-to-agency interoperability at the scene of an incident. This interoperability can be provided to the participating agencies regardless of the system infrastructure coverage at the site of the incident.

2.2.1 JPS ACU-1000 Audio Switch

JPS Communications, Inc. provides a highly portable audio switch called the ACU-1000. It is a rack-mountable card cage that can be equipped with a variety of interface cards, as shown in Figure 11. These cards can interface to portable radio units, mobile radio units, radio base stations, cellular telephones, land line telephone service, or land line radio control circuits. The ACU-1000 is field programmable either from a local keypad or via an interface port to a personal computer. This allows the field operator to change the configuration of the ACU-1000 on the fly as the incident requirements change. The ACU-1000 requires a radio-specific interface cable for each type of radio with which it must interface. This implies that a certain amount of pre-incident planning is necessary. The IPT decided that one JPS ACU-1000 audio switch, containing a full complement of interface cards, and a set of identified radio interface cables would be supplied to each of the three counties participating in the IPT: Monroe, Dade, and Broward.

Figure 11
JPS ACU-1000 Audio Switch

2.2.2 Motorola Model T99DX091W_Astro VHF Mobile Radio Unit

There was a specific need to provide mobile interoperability to the agencies in south Florida that operate in the VHF frequency band. These agencies are primarily federal and include the FBI, INS, and USCG. Three Motorola VHF mobile radio units capable of 128 conventional VHF channels were ordered to support the pilot test solution. These radios were shipped to the FBI radio shop in Miami, Florida, to be checked out and programmed for the desired interoperability channels. Each radio became part of the ACU-1000 package assigned to the three counties in south Florida. Each county agreed to operate and maintain the MASS for its area of responsibility.

2.3 Other Methods of Interoperability for South Florida

The following sections describe methods other than the LCIDC and the MASS that IPT used to establish interoperability among the agencies involved in the pilot project.

2.3.1 Direct Radio Link on VHF Frequencies

Because of the relatively long distance between Border Patrol dispatch in Pembroke Pines, Florida, and U.S. Customs Service (USCS) dispatch in Orlando, Florida, and the infrequent need for USCS personnel to have interoperable radio communications with the agencies of the South Florida IPT, the IPT decided the best approach for interoperability with USCS personnel was through the sharing of one or more VHF radio channels. In this case, predetermined VHF radio channels would be programmed into the radio units of the agencies desiring interoperable radio communications with USCS. This approach could be extended to include any other agencies operating in the VHF High Band. This solution would allow direct radio-to-radio contact without using a LCIDC or MASS approach.

2.3.2 Direct Radio Link on High Frequencies

When a need for interoperable radio communications exists between an INS agent and an offshore USCG vessel, the land-based VHF radio system infrastructure may not be able to reach the offshore vessel. Although addressing this communications challenge was not a formal part of the pilot project, the USCG identified a high frequency (HF) radio channel, operating in the single sideband (SSB) mode, to provide direct radio-to-radio communications. Depending on the exact frequency chosen and the atmospheric conditions at the time, this approach can allow extended communications distances of up to several hundreds of miles.

2.3.3 800 MHz Mutual-Aid Frequencies

The 800 MHz mutual-aid frequencies constitute both tactical and calling channels used extensively throughout the south Florida area. These channels allow interoperability among all agencies with 800 MHz trunked and conventional radio systems. These mutual-aid channels are licensed as conventional, non-trunked channels to allow users of disparate trunked 800 MHz radio systems and conventional 800 MHz radio systems to have radio-to-radio interoperability as needed. Agencies such as Miami-Dade PD have mutual-aid base stations connected to their console switches, thereby providing access to the LCIDC interoperability solution for many outside agencies with the ability to access those mutual aid base stations.

3. SYSTEM IMPLEMENTATION

To provide the desired LCIDC console-to-console interoperability, significant console electronics upgrades and programming work were required. The dispatch center at the Border Patrol location in Pembroke Pines, Florida, was chosen to be the "hub" of the console-to-console interoperability solution for south Florida. This meant that a significant amount of new equipment and installation work was necessary to bring the CEB up to the required level of performance. All the other participating agencies' console electronics switches also required varying levels of new equipment and reprogramming work to accommodate the console-to-console interoperability solution.

To provide the desired interoperability communications for radio units at the scene of an incident, a mobile audio switch was provided to each county participating in the IPT. The audio switches and the identified radio interface cables were ordered and supplied as requested by the IPT. In addition, a Motorola VHF[AGP1] mobile radio unit was supplied to each county as part of the mobile MASS package.

3.1 Implementation of the LCIDC Interoperability Solution

Each agency was responsible for evaluating its console electronics switch and providing the IPT with the requirements to upgrade its switch to the required level of performance. The required equipment and services were then ordered as requested by each agency to upgrade its respective console electronics switch to the required level. The necessary leased four-wire telephone circuits were ordered to provide the agency-to-agency connectivity for the LCIDC interoperability solution. The IPT also ordered a Motorola desktop 800 MHz trunked radio to provide the requested RF link between the Border Patrol dispatch location and the Broward County SO dispatch location.

3.1.1 Upgrade of the Motorola CEB at Border Patrol Dispatch Center

This particular upgrade was the most complex part of the LCIDC interoperability solution to implement. The CEB at the Border Patrol location in Pembroke Pines[HS2], Florida, was operating at full capacity and could not be expanded to accommodate new four-wire leased telephone circuits. This meant that a significant upgrade to the CEB was required. To accommodate the additional connectivity to the new leased telephone circuits and the new Motorola 800 MHz desktop radio, an additional five BIM cards were required. These cards would interface to the Motorola desktop radio at the Border Patrol dispatch center and the leased circuits from USCG, FBI, Monroe County SO, and Miami-Dade PD. The leased circuit from Border Patrol to FDLE/FHP was installed prior to the beginning of the South Florida Pilot Project.

To expand the capabilities of the CEB at the Border Patrol location, an INS technical team recommended an upgrade to the Motorola Embassy™ configuration. This would allow accommodation of the new desktop radio and leased telephone circuits for the LCIDC interoperability solution. The upgrade was accomplished, and the console positions were programmed to display the new connectivity. Each circuit was tested from the Border Patrol

dispatch center at to each participating agency. The radio link to Broward County SO was also tested and verified to be satisfactory. The desktop radio, however, was programmed for a trunked talk group on the Broward County Motorola trunked system, as well as a conventional 800 MHz mutual-aid channel, and was unable to switch over to the mutual-aid calling channel to receive requests for interoperability patches. The problem was traced to a console programming issue at the Border Patrol. After the INS technical group tried for several weeks to resolve the problem, the IPT recommended installation of a leased telephone circuit between the Border Patrol location and the Broward County SO location. The recommended circuit was then ordered. The Motorola desktop radio at Border Patrol was configured for the desired mutual-aid channel, and it now provides a method for other agencies to request an interoperability patch. The leased circuit provides the LCIDC patch connectivity to Broward County SO. This new leased circuit required a sixth BIM card to be activated in the CEB at Border Patrol, and the consoles were reprogrammed to provide access to the new leased telephone circuit. [HS3]The dispatch console position at Border Patrol in Pembroke Pines is shown in Figure 12.

Figure 12
Border Patrol Dispatch Console

3.1.2 Upgrade of the Motorola CEB at USCG

The Motorola CEB at the USCG dispatch center needed an additional BIM card to interface to the new leased telephone circuit from the Border Patrol Dispatch location in Pembroke Pines[HS4], Florida. The USCG representative said that USCG would provide the additional hardware for the upgrade and have its maintenance contractor do the installation and reprogramming of the CEB and dispatch consoles. The USCG ordered and implemented the

hardware, but the maintenance contractor could not reprogram the CEB and dispatch consoles because of the age of USCG system. The maintenance contractor said that it might be necessary to replace the CEB and dispatch consoles with newer equipment. Further investigation by the PSWN Program team revealed options, other than upgrading to new equipment, available for accomplishing the needed reprogramming of the CEB and dispatch consoles. When contacted, a Motorola service shop affirmed that the existing console could be reprogrammed, and the USCG representative was informed of the available services. This information was relayed to the existing USCG service contractor, and the CEB and dispatch consoles were reprogrammed without further delay. The LCIDC patch then functioned as designed. The dispatch consoles, where the LCIDC patch is implemented, are shown in Figure 13.

Figure 13
USCG Dispatch Console

3.1.3 Connection to the Motorola CEB at FBI

The Motorola CEB at the FBI dispatch location in Miami needed only to be reprogrammed to provide the required connection to the new leased telephone circuit and the console-to-console interoperability patch. The leased circuit connection and the reprogramming of the CEB and dispatch consoles were accomplished by the FBI technical staff in Miami. Due

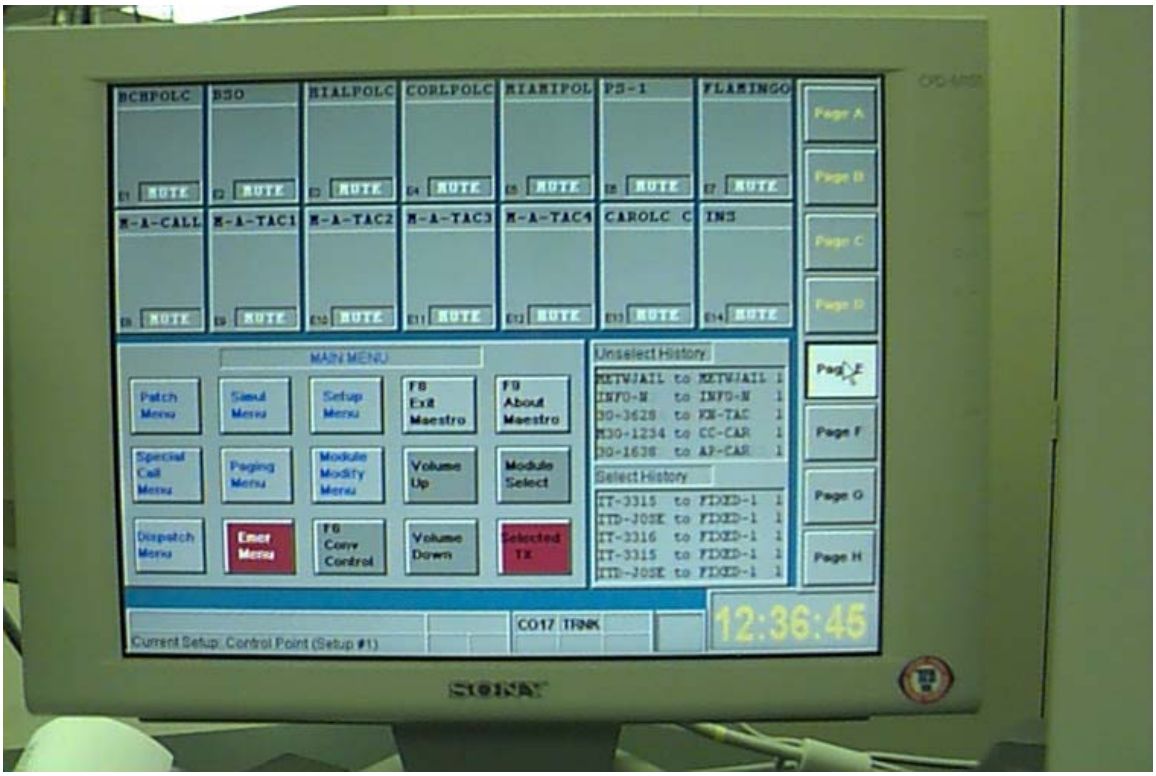
to circuit problems, there were some initial performance problems, but the FBI technician and the INS technician resolved them. The LCIDC between Border Patrol and the FBI now operates as designed. Figure 14 shows the dispatch console where the LCIDC patch is implemented.

Figure 14
FBI Dispatch Console

3.1.4 Upgrade of the M/A-Com CES at Miami-Dade PD

The M/A-Com CES at Miami-Dade PD did not have the additional capacity needed to add the leased telephone circuit for the LCIDC interoperability solution. The Miami-Dade technical staff installed the equipment into the CES and reprogrammed the CES and the console dispatch positions shown in Figure 15. The technician then tested the four-wire leased telephone circuit, set circuit levels, connected the circuit to the CES, and tested the LCIDC from end-to-end with the Border Patrol technician at Pembroke Pines. The LCIDC between Miami-Dade PD and the Border Patrol now operates as designed.

Figure 15
Miami-Dade PD Dispatch Console



3.1.5 Connection to the Motorola CEB at Broward County SO

The Broward County SO initially informed the IPT that it did not want to connect another leased telephone circuit to its CEB. The desired means of providing the console-to-console interoperability was through an RF link with the dispatcher at Border Patrol in Pembroke Pines, Florida. The required Motorola desktop radio was ordered, as well as the antenna and coaxial cable, to provide the requested connectivity. The Broward County technician programmed the desktop radio and returned it to Border Patrol for installation by the INS technician. The INS technical staff installed the radio, coaxial cable, and antenna, and programmed the CEB and dispatch consoles at Border Patrol to accommodate the new RF link to Broward County.

The CEB at Border Patrol could not successfully control the Motorola desktop radio to switch it from a trunked talk group to a conventional mutual-aid channel. After several unsuccessful attempts to reprogram the CEB, the IPT requested that another leased telephone circuit be ordered to connect the Border Patrol Dispatch Center to the Broward County SO. The CEB at Broward County SO was reprogrammed to accept the new leased telephone circuit, and the additional circuit was ordered and installed. The Broward County SO technician checked and set the circuit levels with the INS technician, and the LCIDC now operates as designed. The Motorola desktop radio provides the Border Patrol Dispatcher with access to the 800 MHz mutual-aid channel. This allows other agencies to request an LCIDC patch to the Border Patrol dispatcher via the 800 MHz mutual-aid calling channel. The Broward County SO dispatch console is shown in Figure 16.

Figure 16
Broward County SO Dispatch Console

3.1.6 Connection to the Motorola CEB at Monroe County SO

The Monroe County SO CEB at Marathon, Florida, required the longest leased telephone circuit of those required for the South Florida Pilot Project because it is the farthest away from the Pembroke Pines location. The Monroe County CEB was already equipped to handle an additional four-wire leased telephone circuit, and the Monroe County technical staff programmed the CEB and dispatch consoles to provide access to the LCIDC interoperability with the Border Patrol Dispatch center in Pembroke Pines, Florida. The INS technician and the Monroe County

technician tested the circuit and set levels, and the LCIDC interoperability solution now operates as designed. This circuit is used by INS and Monroe County almost daily to handle immigration issues in Monroe County. A digital picture of the Monroe County SO dispatch console was not available for this report.

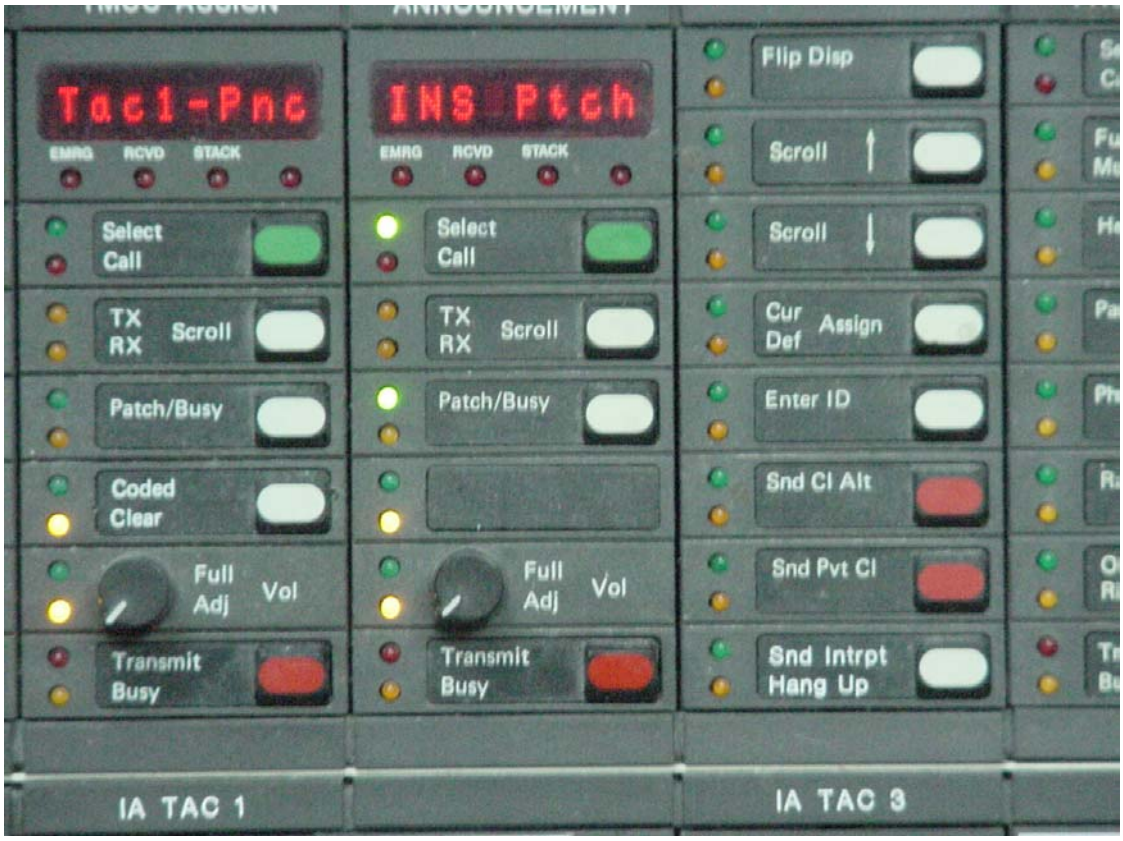
3.1.7 Upgrade of the Motorola CEB at FDLE/FHP

The leased telephone circuit between Border Patrol and FDLE/FHP was installed prior to the start of the South Florida Pilot Project. It was installed and tested by the INS technician and FHP prior to the installation of the other leased telephone circuits between the Border Patrol CEB and the other agencies participating in the IPT. In recent testing, it was noted that the LCIDC interoperability solution did not function as designed when attempting to patch an FHP unit through the FDLE CEB to an INS unit patched through the Border Patrol CEB. The FHP unit could successfully talk out through the LCIDC patch to the INS unit, but the FHP unit could not hear the INS unit through the LCIDC patch. Further testing pointed to an improperly configured BIM card. This problem was resolved when the FDLE technician reprogrammed the CEB to accommodate the new BIM card interface to the leased circuit that provides the console-to-console link to Border Patrol.

Figure 17
FDLE/FHP Dispatch Console

The FHP dispatch center provides patching capability between FHP radio units and INS radio units. An active FHP dispatch position is shown in Figure 17. The FHP dispatcher can initiate the LCIDC interoperability link from the console dispatch position as shown in Figure 18. The button and light-emitting diode (LED) type console has a display window showing the alphanumeric designator for the agency being patched to the Motorola CEB at FDLE.

Figure 18
FDLE/FHP Dispatch Console Patch Detail



3.2 Implementation of the MASS Interoperability Solution

The LCIDC interoperability solution provides a high level of interoperability whenever incidents requiring multiple agencies to respond are located in an area that has radio coverage provided by each of the responding agencies' radio system infrastructures. When this is the case, patching two or more system infrastructures via the console electronics switches of each participating agency provides the needed interoperability in the incident area. At times, however, incidents will occur in areas not receiving radio coverage from the system infrastructures of all participating agencies. In those cases, another method for providing interoperable radio communications must be deployed.

The MASS is a mobile audio switch that provides radio communications between agencies with disparate radio systems when they must interoperate in areas that do not receive

radio coverage from their respective radio system infrastructure. It can provide interoperability between several different radio equipment types and radio system infrastructures.

The ACU-1000 is the interoperability "engine" behind the MASS. It functions much like a small mobile version of a console electronics switch. It can interface to several equipment types, including portable radio units, mobile radio units, base station radios, leased telephone circuits, regular telephone lines, and cellular telephones. The ACU-1000 has 12 card cage positions that can hold a variety of interface cards. It has a microprocessor that can set up and knock down patches between the various interface cards in the card cage. A local operator can configure and operate the ACU-1000 on site to allow quick response to changes in incident requirements. Radio units can be added and deleted as required at the incident site.

3.2.1 Configuration of the JPS ACU-1000 Audio Switch

Because the ACU-1000 is mobile, it can be deployed as needed and moved as the incident requirements change. The fixed LCIDC interoperability solution is very powerful, but it is limited to a fixed radio coverage area. One ACU-1000 unit can interface up to a total of 12 different types of equipment and/or circuits and provide up to a maximum of 7 simultaneous links between the 12 ports. Two of the ACU-1000 units may be linked together for a total of 24 available ports that could be linked together.

The ACU-1000 can provide system-to-system patches, much like the LCIDC does, by utilizing leased telephone circuits or RF links. If the incident is out of the range of system infrastructure, the ACU-1000 can link a variety of mobile and portable radios together in a conventional mode to provide on-site interoperable communications. While the units would not likely have radio contact with their respective system infrastructures, the ACU-1000 audio switch provides a means for direct, on-site, agency-to-agency radio communications.

3.2.2 Provision and Programming of the Motorola VHF Mobile Radio Units

A Motorola VHF mobile radio unit was provided to be permanently attached to an associated ACU-1000 audio switch to provide interoperability with agencies that use the VHF frequency band in south Florida. Each county that participated in the IPT for the South Florida Pilot project received an ACU-1000 audio switch fully populated with 12 interface cards, a Motorola VHF mobile radio unit, and the requested interface cables that would interface with the mobile and portable radio units expected to be used at an incident site. The three Motorola VHF mobile radio units were programmed by a technician at the FBI radio shop in Miami. The frequencies anticipated to be needed in the VHF band were programmed into each radio. The radios are capable of storing up to 128 different radio channels, thus allowing system access by as many agencies as may be necessary at an incident site. After the radios were programmed by a FBI technician, they were distributed to the three south Florida counties for inclusion in the MASS packages.

4. FIELD TESTING AND OPTIMIZATION

After the hardware was installed by the participating agencies and the console audio switches and dispatch consoles were programmed, it was necessary to actually test the operation of the LCIDC under field conditions. Formal tests were coordinated through the IPT to evaluate the effectiveness of the LCIDC interoperability solution.

The MASS equipment had been distributed to the three counties in south Florida, but it had not yet been put into operation. Monroe County had plans to replace the existing audio switch in its emergency communications van with the new MASS. Miami-Dade PD had plans to install the MASS in an emergency communications van in the near future. As of this writing, Broward County does not have a firm plan for deploying its MASS interoperability solution. As of this report date, the MASS interoperability solutions have not been optimized or deployed for any field exercises.

4.1 The LCIDC Interoperability Solution

Field tests were coordinated with the IPT and subsequently conducted in the Miami, Florida, area to test the performance of the LCIDC interoperability solution. These tests were conducted at selected locations in south Florida, near Miami, to emulate "real world" conditions. Refer to Figure 2, which shows the basic system diagram, for clarification of the field test procedures that were performed. The results of these tests are detailed below.

4.1.1 LCIDC Field Test: July 14, 2000

The first official field test of the LCIDC interoperability concept was held on July 14, 2000, at Miami Beach, Florida. The purpose of this test was to determine the approximate delays of console-to-console patching between agencies and to evaluate the overall quality and usefulness of the LCIDC interoperability solution. Three tests were performed to evaluate the patching capabilities.

In the first test, the Border Patrol dispatcher created a console-to-console patch with the FDLE dispatcher so that an INS mobile unit could talk directly with an FHP unit. Both field units were at the test site, allowing the delay from PTT of one radio to received audio at the other unit to be easily monitored. The audio delay associated with this scenario was approximately 1 second. However, the leased telephone circuit between the Border Patrol and the FDLE was not operating in both directions. The FDLE mobile unit could "hear" the INS mobile unit, but the INS mobile unit could not "hear" the FDLE mobile unit. The test was deemed a success with the assumption that the delay should be the same in both directions.

In the second test, an INS mobile unit requested connectivity with a Miami-Dade portable unit. This path extended from the INS mobile unit to the Border Patrol dispatch center, the Border Patrol dispatch center to the FDLE dispatch center, the FDLE dispatch center to the Miami-Dade dispatch center via an 800 MHz mutual-aid channel, the Miami-Dade dispatch center to an 800 MHz trunked radio talk group, and finally to the Miami-Dade trunked portable radio unit. When these connections were made, the INS mobile unit could talk directly to the

Miami-Dade portable unit. Again, the return path to Border Patrol did not work, but the delay on the Border Patrol to Miami-Dade path could be evaluated. By carefully watching the INS field unit operator and monitoring the Miami-Dade portable radio, it was determined that the delay from PTT of the INS unit to start of audio from the Miami-Dade portable radio was approximately 2.5 seconds. This was deemed satisfactory for the test purposes, with the consideration that the delay would be reduced once the leased telephone circuit was installed between Border Patrol and Miami-Dade PD.

In the last of the three tests, a request for connectivity with a Miami Beach portable unit was initiated from an INS mobile unit. This path extended from the INS mobile unit to the Border Patrol dispatch center, the Border Patrol dispatch center to the FDLE dispatch center, the FDLE dispatch center to the Miami-Dade dispatch center via an 800 MHz mutual-aid channel, the Miami-Dade dispatch center to the Miami Beach dispatch center via an 800 MHz radio link, the Miami Beach dispatch center to an 800 MHz trunked talk group, and finally to the Miami Beach portable radio unit. When these connections were made, the INS mobile unit could talk directly to the Miami Beach portable unit. Again, the return path did not work, but the delay on the Border Patrol to Miami Beach path could be evaluated. By carefully watching the INS field unit operator and monitoring the Miami Beach portable radio, it was determined that the delay from PTT of the INS unit to start of audio from the Miami Beach portable radio was approximately 4 seconds. This test was deemed satisfactory for the intended purpose of the LCIDC interoperability solution, with the consideration that the leased telephone circuit, soon to be installed between the Border Patrol and Miami-Dade PD, would reduce the delay time.

4.1.2 LCIDC Field Test: June 7, 2001

The second official field test of the LCIDC interoperability solution was held on June 7, 2001. Each participating agency in the IPT had installed the required equipment, programmed its respective console switches, and connected, tested, and set levels on the leased telephone circuits. An additional leased telephone circuit had been installed between the Border Patrol CEB and the Broward County CEB. The readiness of each participant was verified, and the test commenced at 10:15 a.m. local time.

The purpose of the test was to verify the patching capability between each of the participating agencies and Border Patrol, using the established four-wire circuits. The plan was to test each agency's console-to-console link with the Border Patrol dispatch console at Pembroke Pines. The final test of each LCIDC patch consisted of having a subscriber unit from each agency talk with a subscriber unit from INS through the patch. This test would verify each agency's link with the Border Patrol location. Further testing of the patching capabilities of the Border Patrol console electronics at Pembroke Pines could be accomplished by the participating agencies at any time. Additional testing might involve, for example, simultaneous patching of two or more outside agencies together via the console-to-console patch feature of the Border Patrol CEB.

The field test began when an INS mobile radio operator initiated a link by calling the Border Patrol dispatcher and asked for a patch to the USCG portable radio unit located at the test site. The USCG unit was then patched through the Border Patrol console for a test between the

INS mobile unit and the USCG portable unit. The link was successful—the two radio operators were able to communicate through the LCIDC patch.

The Border Patrol dispatcher then attempted to create a patch between the Border Patrol console and the FHP console. Several attempts indicated that the leased telephone circuit providing the connectivity was not working properly, and therefore the test was not successful. FDLE indicated it would look into the problem at the first opportunity. Further investigation by FDLE revealed that the CEB programming at the FDLE facility needed to be changed to accommodate the LCIDC interoperability solution. It was determined that when the LCIDC was initiated, the patch audio coming into the FDLE CEB from an outside agency was not being patched through to the user, i.e., the FHP radio operator.

Next, the Border Patrol dispatcher created a patch between the Border Patrol console and the FBI console. Each dispatcher then patched in the appropriate field units so that the INS operator (on a mobile unit) could talk directly to the FBI operator (on a portable unit). The patch worked properly, and the radio operators were able to communicate with each other.

The Border Patrol dispatcher then attempted to create a patch between the Border Patrol console and the Broward County SO console. This test was not successful because of what appeared to be weak audio levels on the leased telephone line. The Broward County SO radio operator at the test location was unable to reach the Broward County trunked radio system from the test location. An attempt to patch a Broward County mobile radio unit, located in Broward County, over the leased telephone circuit into the Border Patrol console was not successful, and the INS radio operator was unable to talk directly to that Broward County radio operator. It was determined that further testing of the leased telephone circuit between the Border Patrol location and the Broward County S.O. location would be needed. The resolution to this problem was to evaluate the audio quality of the leased telephone circuit between the Broward County SO CEB and the Border Patrol CEB and then to set the proper audio levels to optimize the circuit.

The Border Patrol dispatcher then contacted the Miami-Dade PD dispatcher to set up a console-to-console patch. Several attempts revealed that the leased telephone circuit was not functioning, and the patch was not successful. The Miami-Dade technical team promised to look into the circuit problem at the first opportunity. The leased telephone circuit problem was repaired, and the Border Patrol and Miami-Dade PD tested the LCIDC during the week of July 2, 2001. On July 5, 2001, the INS reported that the LCIDC link between Border Patrol and Miami-Dade PD was operating as designed.

4.1.3 LCIDC Field Test: July 31, 2001

The first test was to initiate a console-to-console link between the Border Patrol and the FBI. The INS technician attempted to contact the FBI using the intercom function of the Border Patrol dispatch console. The FBI dispatcher responded by saying that audio quality was good. Next, the INS technician asked the FBI dispatcher to patch an FBI field unit through the console-to-console connection. The FBI technical supervisor assisted the FBI dispatcher in setting up the console-to-console patch. The INS technician used a portable INS VHF radio unit to talk

through the patch to the FBI supervisor's portable VHF radio unit. The patch was tested in both directions, and it worked as designed.

The second test was to initiate a console-to-console link between the Border Patrol and Miami-Dade PD. The first attempts to contact Miami-Dade PD through the console intercom feature were not successful. Next, the Border Patrol dispatcher tried to contact Miami-Dade PD through the mutual-aid channel. The dispatcher responded, and the Border Patrol dispatcher requested an interoperability patch using the console-to-console leased circuit. After a short delay, the patch was set up, and the INS technician, using an INS VHF portable radio unit, was able to communicate successfully with a Miami-Dade PD field unit over the console-to-console patch.

The third test was to initiate a console-to-console link between the Border Patrol and the Broward County SO. The Border Patrol dispatcher attempted to contact the Broward County SO dispatcher using the identifier "Broward County." The Broward County SO dispatcher did not respond until the Miami-Dade PD dispatcher relayed the message as "BSO." The Broward County SO dispatcher did not recognize the identifier "Broward County" because they typically use the identifier "BSO." With that clarification, the Border Patrol dispatcher was able to contact the Broward County SO dispatcher over the console-to-console link. The Border Patrol dispatcher then requested a patch to a Broward County SO field unit to evaluate the console-to-console interoperability. The Broward County SO dispatcher noted that no field units were available at that time. After approximately 20 minutes, the Broward County SO dispatcher called the Border Patrol dispatcher and stated that a Broward County SO unit was now available for the interoperability testing. The patch was set up, and the INS technician, using a VHF portable unit, was able to communicate successfully with the Broward County SO mobile unit in the field.

The fourth test was to initiate a console-to-console link between Border Patrol and the FHP/FDLE. The FHP dispatcher did not respond to the intercom audio when the Border Patrol dispatcher called. The FDLE was contacted by telephone to determine whether the console programming issues at the FDLE had been resolved. The FDLE supervisor responded in the affirmative, and went to the dispatch center to facilitate the testing. The FHP dispatcher then responded, and the console-to-console link was established. The FDLE dispatcher created the patch to the supervisor's portable radio unit, and the Border Patrol dispatcher created a patch to the INS technician's VHF portable radio unit. The INS technician then talked directly to the FDLE supervisor, thus successfully demonstrating the patch between the two agencies.

The fifth test was to initiate a console-to-console link between Border Patrol and the Monroe County SO. The Border Patrol dispatcher attempted to contact the Monroe County SO dispatcher by using the intercom feature of the consoles. The Monroe County SO dispatcher did not respond immediately. After several minutes, the Monroe County SO did respond to the Border Patrol dispatcher, and the console-to-console link was established. Next, the Border Patrol dispatcher asked the Monroe County SO dispatcher to patch a field unit through the console-to-console link. With this accomplished, the Monroe County SO field unit communicated successfully with the INS technician's portable radio unit, thus successfully demonstrating the patch between the two agencies.

The final test was to initiate a console-to-console link between Border Patrol and USCG. The Border Patrol dispatcher attempted to contact the USCG dispatcher using the intercom feature of the consoles. After several minutes of trying, there was still no response. The USCG dispatcher was then contacted by telephone in an attempt to set up the console-to-console patch. The USCG dispatcher informed the Border Patrol dispatcher that the console microphone was defective and that console repairs were pending. The USCG dispatcher and the Border Patrol dispatcher then attempted to set up a console-to-console patch because the microphone was not necessary to operate that patch. After approximately 30 minutes, it was determined that the patch either would not work, or could not be established, and the effort was cancelled. The Border Patrol dispatcher was unable to establish a console-to-console link and subsequent field unit-to-field unit patch with USCG. The USCG officer in charge of communications was out until August 3, 2001, so he could not be contacted at the time of the test for assistance. The console was repaired at a later date, and the Border Patrol and USCG t tested and verified that the console-to-console link was working properly.

4.2 Testing and Optimization of the MASS

The MASS interoperability solution has been distributed to each of the three counties participating in the pilot project: Monroe, Broward, and Miami-Dade. To date, there has been no indication that these packages have been field tested or used in any scenarios that would benefit from mobile interoperability capabilities.

5. SYSTEM TRAINING

The Miami-Dade PD wrote the patching procedure to set up and knock down the LCIDC interoperability solution. This procedure has been distributed to the IPT, and each agency has assumed responsibility for providing ongoing training to its dispatch personnel, as well as the radio users in the field. The IPT is also working to ensure that the LCIDC interoperability solution is tested on a regular basis to ensure it operates properly when needed.

The Miami-Dade PD has also offered to take the lead in writing the operational procedure for the proper usage of the MASS. To date, the MASS has not been installed and configured for field interoperability use because of other priorities within the participating agencies. The agencies envision that when they are ready, they will each provide training for their own personnel prior to deployment of the MASS.

The South Florida IPT invited a representative from JPS Communications, Inc., to attend an IPT meeting and provide a 1-day seminar on the programming and use of the ACU-1000 audio switch. Roger Williams (JPS Communications, Incorporated) provided the training, at no charge, using JPS training equipment. The ACU-1000 used in the training was mounted in a carry case along with two mobile radio units, one a VHF unit and the other a UHF unit, and a DC power supply. Mr. Williams also brought along two portable radio units, one a VHF unit and the other a UHF unit. The training was conducted using all radios in the simplex, or "talk around" mode so that access to outside repeaters was unnecessary.

Mr. Williams started out by describing the ACU-1000 audio switch and its features and functionality. He described each module that could be used in the ACU-1000 and how it interfaced to different communications devices such as mobile and portable radio units, two-wire analog telephone lines, cellular telephones, and any four-wire circuit such as microwave channels, fiber optic channels, or leased telephone circuits.

The next step was to demonstrate how the PC interface was used to select and operate the different functions of the ACU unit. Mr. Williams stated that the most powerful user interface to the ACU-1000 was via the PC port. He demonstrated how to set up connections between the various cards installed in the ACU and connected to the internal radios and the analog two-wire telephone line. He showed how, as each connection was established on the PC screen, the interconnected units were activated, and the link performance was demonstrated.

6. CONCLUSIONS AND OBSERVATIONS

During the course of the project, many challenges were addressed by the IPT, and, in the end, this interoperability pilot project provided a much-needed communications enhancement for the participating agencies. The coordination and cooperation of the participating agencies were key factors in producing a practical and effective interoperability solution, allowing wireless communications between the users of disparate conventional and trunked radio systems. Listed below are some of the key lessons learned from this pilot project:

- The IPT must reach consensus on the configuration for the interoperability solution that will best meet the needs of the various participating agencies.

- Leased telephone circuits must be tested on a regular basis to ensure they are working properly so they can be used for routine or emergency communications.

- When designing a console-to-console interoperability solution, the relative advantages and disadvantages of leased telephone circuits versus radio frequency links must be carefully weighed.

- When scheduling the installation of pilot project equipment, the IPT must be cognizant of the staffing levels of each participating agency and the workload placed on the technical personnel that must install and optimize the equipment. Public safety agency mission requirements often dictate that priorities be reassessed on a daily basis. Technical support personnel cannot always immediately respond to pilot project initiatives because of higher priority responsibilities. Proactive communication between the IPT members and local support staff to identify the need for additional resource requirements can alleviate challenges associated with conflicting priorities. In the end, patience and persistence is key to the success of the pilot project.

- The IPT is the driving force behind the successful completion of the project. IPT members should regularly monitor project progress and identify additional technical support, as required, when project requirements exceed the expertise of on-site technical staff. This may include identifying available technical training courses or inviting subject-matter experts to assist in moving the project forward.

- The IPT must regularly monitor project progress to ensure interoperability needs are satisfied by the proposed solution. Because most interoperability solutions are composed of a technical component as well as an intergovernmental agreement component, the IPT must consist of the appropriate blend of technical and management personnel to ensure the success of the project.

- Personnel from public safety agencies may not be able to attend IPT meetings on a regular basis because of higher mission priorities. The IPT, therefore, must keep accurate notes and generate detailed meeting minutes for all IPT members to ensure the entire project team is informed of project status and other developments.

- Often, the technical solution to an interoperability challenge is easier to address than the intergovernmental aspects of the given situation. Sensitivity to local, state, and federal agency needs is paramount to project success.

- The IPT must verify that the list of required components to implement the interoperability solution is complete prior to accomplishing the site survey. The site survey should be used to verify all identified components would function as designed when installed at the existing site. The site survey also provides the data needed to develop the final design of the interoperability solution. Available rack mounting space, antenna tower mounting space; heating, ventilation and air conditioning (HVAC) capacity; AC power capacity; uninterruptible power supply (UPS) capacity; and backup generator capacity are examples of information that should be gathered during site surveys.

- The IPT must conduct an ongoing dialog with the pilot project's participating agencies and associated support staff. If mission requirements or other routine responsibilities appear to be causing delays in project progress, it is incumbent on the IPT to maintain project momentum by exploring options such as subcontracting small portions of work to local service shops to facilitate stalled project activities. Agreements must be established early in the pilot test process relative to how this, or other like options, would be addressed as the needs arise.

- When performing interoperability field-testing between multiple agencies, the IPT must appoint someone to manage the testing. Although a written test procedure was provided for the second field test of the LCIDC, there was no field test director assigned to ensure the testing would be accomplished in a logical and methodical manner. As a result, the Border Patrol dispatcher was inundated with requests for LCIDC interoperability patches from all of the participating agencies at the same time, resulting in poor test performance.

- During the course of the pilot project, it seemed there was some reluctance on the part of local agencies to work closely with federal agencies to resolve system problems. If such issues should arise, the IPT must be prepared to facilitate communications among all participating agencies to ensure timely and successful implementation of the interoperability solution.

APPENDIX A—ACRONYMS

BIM	Base Interface Module
BP	Border Patrol
CEB	Console Electronics Bank
CES	Console Electronics Switch
CIC	Conventional Interface Card
COTS	Commercial Off the Shelf
FBI	Federal Bureau of Investigation
FDLE	Florida Department of Law Enforcement
FHP	Florida Highway Patrol
HF	High Frequency
HVAC	Heating, Ventilation, and Air Conditioning
INS	Immigration and Naturalization Service
IPT	Integrated Program Team
LCIDC	Leased Circuit Interconnection of Dispatch Consoles
LED	Light Emitting Diode
LMR	Land Mobile Radio
MASS	Mobile Audio Switching System
MHz	Megahertz
PD	Police Department
PMO	Program Management Office
POTS	Plain Old Telephone Service
PSWN	Public Safety Wireless Network
PTT	Push to Talk
RF	Radio Frequency
SO	Sheriff's Office
SSB	Single Sideband
UHF	Ultra High Frequency
UPS	Uninterruptible Power Source
USCG	United States Coast Guard
USCS	United States Customs Service
VHF	Very High Frequency
VOX	Voice Operated Transmit