PUBLIC SAFETY
PSWN PROGRAM
WIRELESS NETWORK

Saving Lives and Property Through Improved Interoperability

Redcom IGX ISDN Gateway Exchange Assessment

Final

July 2002

PREFACE

This report assesses the available technical information on the Redcom IGX switch. This switch can support interoperability among public safety wireless networks. Its use is appropriate when public safety personnel operating in certain response scenarios would benefit from support by a mobile or fixed augmentation of the public safety agencies' communications infrastructure. This report is the basic, essential resource for all public safety agencies interested in such a solution. More information on the Redcom IGX switch and other approaches for achieving interoperability are available from the Public Safety Wireless Network (PSWN) Program, which sponsored and funded this technical analysis. 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.

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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 program works with the public safety community to improve the interoperability of wireless communications systems 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.

1.1 Background

What is interoperability? Interoperability refers to the ability of public safety personnel to communicate by radio with personnel from other agencies, on demand and in real time. Public safety agencies require three distinct types of interoperability—day-to-day, mutual aid, and task force.

- Day-to-day interoperability involves coordination during routine public safety operations. For example, day-to-day interoperability is required when firefighters from various departments join forces to battle a structural fire or when neighboring law enforcement agencies must work together during a vehicular pursuit. Typically, the Federal Government does not engage heavily in day-to-day interoperability.

- Mutual-aid interoperability involves a joint and immediate response to a catastrophic accident or natural disaster and requires tactical communications among numerous groups of public safety personnel. Airplane crashes, bombings, forest fires, earthquakes, and hurricanes are all examples of mutual aid events.

- Task force interoperability involves local, state, and federal agencies coming together for an extended period of time to address an ongoing public safety concern. Task forces lead the extended recovery operations for major disasters, provide security for major events, and conduct operations in prolonged criminal investigations.

Switching technology is increasingly becoming an effective way to improve communications interoperability. To date the PSWN Program has implemented three pilot projects using audio relay switches and has learned much about how this technology facilitates interoperability among public safety agencies. The first pilot system was deployed to San Diego County, California, the second was deployed to the South Florida counties, and the third was deployed to the Washington, DC Fire and Emergency Medical Services Department (DC Fire). The solutions deployed in San Diego and South Florida consisted of an advanced audio switch (the ACU-1000) capable of interfacing two-way radios. The solution deployed in Washington, DC consisted of a lower technology solution called the Incident Commander's Radio Interface (ICRI).

DC Fire identified a unique requirement for incident response in Metrorail tunnels requiring a portable interoperability solution. During Metrorail station fire incidents, several different public safety agencies often assist DCFD personnel as part of the initial incident

response. Many of these agencies do not operate on the same frequency band as does DCFD; thus, interoperable communications are limited. To overcome this interoperability challenge, DCFD opted to implement the ICRI Integrated System, a device that transfers audio among radios transmitting in disparate frequencies. The ICRI consists of three basic elements: user portable radios, a portable switch, and interface hardware.

In addition to these pilots, the PSWN Program has held forums for and attended demonstrations of other switching solutions, including Motorola's Wireless Information Transfer System (WITS) interoperability switch and the Department of Defense's Joint Combat Information Terminal (JCIT) (not yet commercially available).

1.2 PSWN Program Switching Analysis

A primary goal of this switching analysis is to add to the PSWN Program knowledge base by providing a better understanding of the switching technology market. Ultimately, this information will enhance public safety agencies' ability to deploy solutions that can dramatically improve interoperability for both day-to-day and emergency response scenarios. As always, with improved interoperability, public safety response efficiency improves as response time decreases. In addition, if agencies can implement switch solutions in the field, they may not need to pursue more elaborate interoperability solutions and can continue to use equipment that would not normally be interoperable.

1.3 Purpose and Scope of This Document

This document presents an overview assessment of the Redcom IGX switching platform. The Redcom IGX switch, which falls into the category of cross-band technology, can be used by public safety organizations to perform wireless communications interoperability between dissimilar wireless systems. The technical analysis of the IGX switch is based on information provided by Redcom and does not include any results from laboratory bench testing.

1.4 Redcom Laboratories Overview

Redcom Laboratories Inc. engages in research and development of electronic switching systems, related test equipment, and software. Its primary headquarters and manufacturing facility is located in a suburb of Rochester, New York. Further information on the Redcom switching products can be obtained directly from Redcom.

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2. Redcom IGX Switch Analysis

2.1 Introduction

The ability to bridge disparate communications systems enhance public safety communications interoperability. The Redcom IGX switch can be used to create such bridges in both fixed and mobile applications. The switch supports many commercial and tactical interfaces, and is expandable to meet future communications requirements.

This section summarizes the PSWN Program's findings from the analysis of the IGX switch, and is organized into the following subsections:

- System Expandability
- Equipment Pricing
- Availability of Radio Interfaces
- Systems and Circuit Interface Availability

A detailed description of the switch hardware is presented in Sections 3 and 4 of this document.

2.2 System Expandability

System expandability is the ability to add new functionality to meet current and future requirements. The cost of adding the new functionality, system engineering requirements, and the effects on day-to-day operations are all considerations when expanding a system. The Redcom switch's design allows expansion. Adding new circuit boards requires inserting the card into the card cage. If the agency required another MSU shelf, it requires mounting the shelf and interconnecting the ribbon cable between shelves. In either case, the IGX system automatically recognizes newly installed circuits or shelves and integrates them into the entire system. Switch upgrades have little or no impact on current operations. It should be noted that if a custom database is used, some administrative database changes might be required.

2.3 Equipment Pricing

Redcom IGX switch pricing varies greatly depending on the application. Section 5.2 describes a sample configuration.

2.4 Availability of Radio Interfaces

Public safety agencies depend on radio communications for their day-to-day and contingency operations. Many of these communication systems do not use the same frequency band, and even when they do, often employ incompatible protocols. Public safety agencies can address these interoperability challenges by connecting radios to a medium that can provide a cross-connect path between the disparate systems. In the IGX switch, the Radio Line Interface (RLI) card interfaces radios to the switch, and the conferencing capabilities of the switch are then used to patch radios together. Detailed information on the RLI and conferencing boards is described below.

2.4.1 RLI and Conference Boards

The RLI board provides flexible radio control for most applications; however, the following design considerations should be kept in mind:

- Prefabricated radio interface cables are not available from Redcom. It would be necessary for the user to procure these cables from the radio manufacturer or a third party vendor.

- There are two possible methods of keying radios, VOX and carrier operated relay (COR). The RLI board supports only VOX keying. Each method has its advantages and disadvantages as explained below:

  – **COR Keying—**COR keying uses a separate keying control signal as illustrated in Figure 1. Radio 1, upon detection of a carrier, generates a DC voltage to the interface card, which keys Radio 2. Radio 1's receive audio is then transmitted by Radio 2.

    ♦ COR keying is generally faster than other methods of keying because of the separate control voltage that is generated.

    ♦ COR keying has two disadvantages. First, noise on Radio 1 can cause false transmissions to occur because any signal received by Radio 1, including noise, is transmitted by Radio 2. Secondly, COR on some radios is not available externally and thus requires internal modifications.

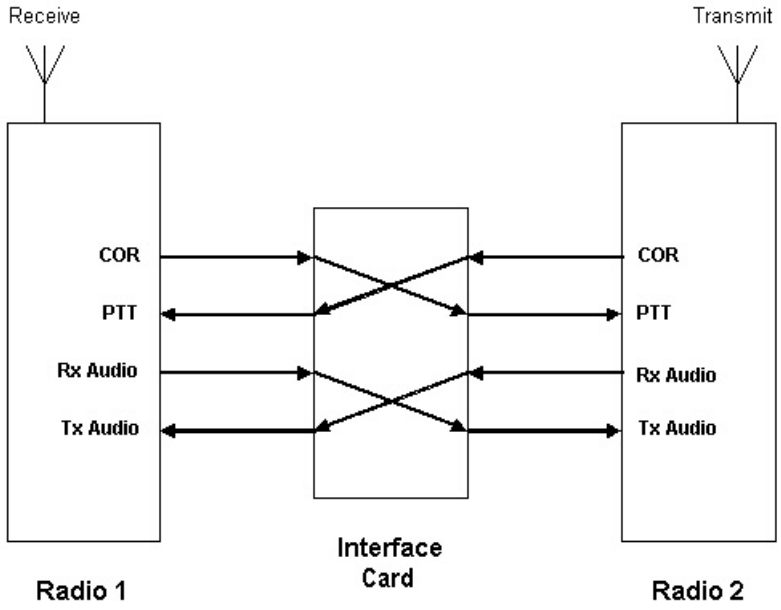

Figure 1
Carrier Operated Relay (COR) Keying

– **VOX Keying—**VOX uses only the audio to key the radio, as illustrated in Figure 2. Radio 1, upon detection of a carrier passes its audio to the interface card. The root mean square (RMS) value of the captured audio is calculated and compared to the value of the VOX level of the interface card. If the RMS value is less than the VOX level, a transmission is not started and the captured audio data is dropped. When the RMS value of the captured audio data is greater than the VOX level, a transmission is started, enabling push-to-talk (PTT) on Radio 2, which then transmits the received audio.

  - ♦ VOX keying has two advantages. First, it can be used with any standard radio. Secondly, false keying of the patch circuit is minimized.

  - ♦ Audio delay is a disadvantage of VOX keying. These delays can cause the beginning of radio transmissions to be truncated. The RLI board has potentiometers that adjust the circuit to minimize the audio delays.

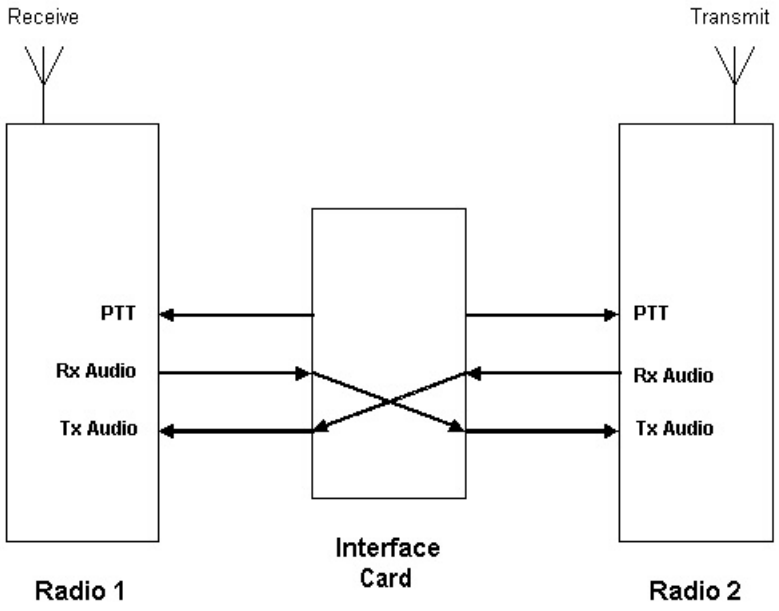

Figure 2
Voice Operated Transmit (VOX) Keying

Any radio connected will have full control of the switch functions. DTMF dialing can be used to establish conference calls, radio patches, and contact telephone subscribers. Furthermore, telephone subscribers can dial into and use connected radios.

2.5 Systems and Circuit Interface Availability

Telephone, radio, and data systems are key to public safety day-to-day and contingency operations. The ability to establish connectivity between all systems greatly enhances communications interoperability between agencies. The IGX switch is a fully functioning, private branch exchange (PBX) that can accomplish this interface, and it supports both analog and digital transmission media. Examples of applications supported include, but are not limited to, analog telephone, land mobile radio, teleconferencing, video teleconferencing, and ISDN terminals. The following is a list of supported circuits and devices:

- Analog subscriber devices (i.e., telephones, facsimile, etc.)
- LSRD/GSRD trunk circuits
- Two-way loop trunk circuits
- T1 and T1 with SS5 signaling trunk circuits
- E1 trunk circuits
- E+M signaling trunk circuits
- Analog SF and analog SF with SS5 signaling trunk circuits
- CEPT and CEPT with SS5 signaling trunk circuits
- ISDN-BRI terminal interface circuits
- ISDN-PRI trunk.

2.6 System Training

Redcom offers two types of training tailored to the customer's application. These classes are either 1 or 2 weeks in length. Class length is based on the level of the customer's switch experience. Customers with experience typically receive the 1-week training class, and customers without experience typically receive the 2-week class.

2.7 System Serviceability and Reliability

Communication systems that are reliable, easily serviced, and have minimal operational impacts during system outages are critical to public safety operations. The following is a list of switch reliability and serviceability characteristics of the IGX switch:

- Circuit boards are installed and removed from the front of the switch.
- Circuit boards can be removed and installed with power applied to the system.
- No special tools are required to perform maintenance.
- The number of spare cards needed is minimal because each MSU is identical.
- Each MSU shelf is self-contained. If one shelf fails in a multiple-shelf IGX system, the remaining shelves would function normally.

3. SYSTEM HARDWARE OVERVIEW

3.1 System Overview

The Redcom IGX switch is a highly customizable hardware platform that can be configured for mobile or fixed applications. At the heart of the IGX design is a common hardware set called the modular switching unit (MSU). The MSU is a self-contained unit with its own power supply and microprocessor. Each IGX shelf consists of the following components:

- Equipment enclosure
- MSU controller board
- Expanded time slot interchange (ETSI) board
- Up to 16 port and service circuit boards (with system engineering)
- Ringing generator or power monitor board
- Power supply.

The MSU equipment enclosure provides mechanical support and circuit board interconnection. It consists of a back plane, alternating current (AC) or direct current (DC) power supply, and ribbon cables to provide interconnection between shelves. The MSU equipment enclosure is mechanically configured to fit into a standard 19-inch rack. A fully equipped enclosure weighs approximately 40–50 pounds, and measures 19 inches wide, 8.75 inches high, and 15.0 inches deep.

The Redcom IGX switch can be as small as a single shelf or as large as eight interconnected shelves. Each shelf contains 18 card slots, 3 of which are used for control cards, and the remaining 15 for port/service cards. Redcom uses ClusterNet technology to interconnect multiple switching sites. This technology allows for the design of very sophisticated systems consisting of more than 10,000 ports. Shown in Table 1 are the Redcom IGX switch general specifications.

Table 1
IGX Switch General Specifications

Item	Specification		
User Ports	– 32–768 per system – 10,000 or more by using ClusterNet technology		
Station Loop	– 1,200-Ohm standard – 1,900-Ohm optional		
Station Dialing	– DTMF, DT, or ISDN – Senderized dialing available – Standard tones (EIA RS-464); special tones available as option		
Power	-48 Volts DC (VDC)/DC converter	24 VDC or 100/120/240 VAC	50–60 Hertz (Hz), optional
Power Consumption		With DC Power	With AC Power
	Idle (watts/shelf)	75–125	100–150
	Average (watts/shelf)	100–150	125–200
Heat Load	– 100–275 watts/shelf; 340–935 BTU/hour/shelf		
Internal Transmission	– Digital 8-bit pulse code modulation (PCM) format – μ-255 Law, A–Law companding optional		
External Transmission	– Crosstalk > -75 decibels (dB) – Idle Circuit Noise: < 23 dBrnc		
Nominal Impedance	600 Ohms		
Environment	0–50 °C 5%–95% relative humidity (non-condensing)		
Shelf Dimension	8.75” H x 19” W x 15.0” D 22 cm H x 48.3 cm W x 40.4 cm D Cable tray adds 1.75” (4.5 cm) to height		

3.2 IGX Switch Circuit Boards

Many types of circuits and devices can be connected to the IGX switch, supporting a variety of switching applications, including both private and public network requirements. The IGX circuit boards that enable these connections can be grouped into three categories:

- **Control Boards—**Common boards required for the switch to function properly
- **Port Circuit Boards—**Circuit boards interfacing the switch to external analog or digital circuits
- **Service Circuit Boards—**Circuit boards supporting the activities of the IGX switch.

Table 2 lists the port and service boards available for the IGX switch. This table is organized into five columns containing the following information:

- **Type of Board**—The system database identifies the IGX switch circuit boards as line, trunk, or service.
- **Board Name—**This column contains the generic name of the circuit board.
- **Circuit Quantity**—This column indicates how many circuits or devices the circuit board supports.
- **Card Slots**—This column indicates how many of the 15 general-purpose slots are required for each circuit board.
- **Time Slots Required**—This column identifies the number of time slots required for each board. As a general rule, one time slot is reserved for every circuit or device the card is capable of supporting. For example, the radio line interface (RLI) card supports four radios and requires four time slots. Each shelf is limited to 96 non-blocking time slots. Up to 8 shelves can be interconnected, providing a capacity of 768 non-blocking time slots.

Table 2
IGX Port and Service Circuit Boards

Board Type	Board Name	Circuit Quantity	Card Slots	Time Slots
Line	Attendant Console	1	1	1
	Basic Rate Interface	4	1	8
	Personal Handy-phone System CS-BRI board	4	1	8
	Dynamic Line Circuit	1-16	2	2-16
	1200 ohm Line Circuit	4	1	4
	1900 ohm Line Circuit	4	1	4
	Radio Line Interface	4	1	8
	Expanded Line Circuit	8	1	8
Trunk	Two-Way Loop Trunk	2	1	2
	Answering Service Interface	4	1	4
	CATS Board	2	1	2
	CEPT 1 Interface	32	2	2-32
	Digital Announcer Type II	2	1	2
	T1 Interface MA0292	24	2	2-24
	E&M trunk, Digital Announcer Type 1	2	1	2
	GSRD Trunk	2	1	2
	LSRD Trunk	2	1	2
	Generic Trunk Circuit Slot	2	1	2
	T1 with SS5 Signaling	24	3	2-24
	CEPT with SS5 Signaling	32	3	2-32
	Analog SS5	2	1	2
	Analog SF	2	1	2
Service	16-Party Conference	16	1	16
	8-Party Conference	8	1	8
	Digital Signal Processor	8	1	2-64
	Digital Test Interface	8	1	8
	DTMF Receiver	2	1	2
	DTMF Receiver/Sender	2	1	2
	MF Sender/Receiver	2	1	2
	MF Sender	2	1	2
	MTI Board	2	1	2
	R1/R2 Receiver/Sender with 4 circuits	4	1	4
	R2 Sender/Receiver	2	1	2
	Generic Service Circuit Slot	2	1	2
	Clock Synchronizer	0	1	0
	ETSI Service Board	32	1	32
	Clock Synchronizer	0	1	0
	Universal Sensor/Driver	8	1	0
	R1/R2 receiver/Sender with 8 circuits	8	1	8

3.2.1 System Control Boards

Three control boards are required in each shelf of the IGX switch stack:

- **MSU Controller Boards—**This is a two-board set consisting of a MSU controller board and MSU supervisor board. This set controls all the activities on the shelf, as well as providing the pulse code modulation (PCM) clock signaling. The MSU controller board also contains the system database. This database stores information on the type of card plugged into each slot, which trunks are in shared groups, and the classes of service for all lines and trunks. The MSU controller board set is plugged into the first two slots of the MSU shelf.

- **ETSI Boards—**The ETSI board functions as the voice matrix of the switch and routes the voice or data between the ports. The IGX switch uses a PCM scheme to transfer analog voice and data between the system ports. Each analog port contains its own CODEC (COder/DECoder), which generates and decodes the PCM stream. The ETSI board routes the PCM data onto the appropriate bus in accordance with its assigned time slot number. The system bus (i.e., port/service highway) allows for 96 user-assignable time slots for circuit cards mounted in the general slots 1–15.

  Each shelf's' ETSI board is responsible for directing its traffic. If the ports to be connected are within the same shelf, then only the ETSI board for that shelf is used. If the ports to be connected are located in different shelves, then the ETSI board in each of the shelves is used. The ETSI board is installed in the third slot from the left and consists of two boards.

- **Ringing Generator Board/Power Monitor Board—**The ringing generator board provides an 85–105 volts root mean square (Vrms) ringing voltage to ring telephone instruments. If a ringing generator board is not required for the application, then an optional power monitor board must be installed in its place. The power monitor board monitors the MSU shelf power supplies. The ringing generator and power monitoring board are installed in the rightmost slot in the MSU. Shown in Table 3 are descriptions of the ringing generator boards available for the IGX switch.

Table 3
Ringing Generator Board Specifications

Board Name	Description
Fixed Frequency	– Standard Version 20 Hz – Alternate versions are available in 25, 30, 40, or 50 Hz.
Selectable Output	– Adjustable from 15–70 Hz in 0.1 Hz increments – Consists of a motherboard and ringing generator module.

3.2.2 Port Circuit Boards

As discussed, IGX circuit boards can be grouped into three categories: control, port, or service. Port circuit boards process analog or digital signals from an external source and convert them into a PCM stream for routing within the system. Port circuit boards can be sub-categorized based on the type of circuit or device to which they interface. These sub-categories include—

- Analog and digital line circuits
- Analog trunk circuits
- Digital trunk circuits.

3.2.2.1 Analog and Digital Line Circuit Boards. Analog line circuit boards interface subscriber station sets such as telephones, radios, and consoles to the IGX switch. Digital line circuit boards interface Integrated Services Digital Network (ISDN) devices to the IGX switch.

Radio Line Interface (RLI) Board—Radios and public address systems interface to the switch using the RLI board. Each radio interfaced to the switch is assigned a station number and has access to the full functionality of the switch. The input and output circuits can be individually adjusted using the provided potentiometers. Because the input and output circuits are adjustable, the user can connect a diverse mix of radios to the switch. Listed in Table 4 are brief descriptions of the two types of RLI boards offered by Redcom.

Table 4
Radio Line Interface Board Specification

Board Name	Description
Push-To-Talk (PTT) Board (MA0522)	– Supports four PTT capable radios, uses four time slots, and occupies one board slot in the IGX shelf.
Voice Operated Transmission (VOX) Board (MA0548)	– Factory-equipped for either very high frequency (VHF) (dual tone multifrequency [DTMF]) or high frequency (HF) (pulsed) operation and are configured as— • Four VHF (DTMF operation) • Four HF (pulsed operation) • Two each VHF/HF circuits. – Offers simplex or duplex VOX operation.

Subscriber Line Circuit Boards—Two-wire dual-tone multi-frequency (DTMF) subscriber devices, such as telephone instruments, facsimile machines, and modems, are connected to the switch using subscriber line circuit boards. Redcom offers a variety of cards to support different applications. Listed in Table 5 are brief descriptions of the cards available from Redcom.

Table 5
Subscriber Line Circuit Boards

Board Name	Description
1,200-Ohm Line Circuit (MA0209-102 MA0209-122)	– Used for circuits that have up to 1,200-Ohm round-trip DC resistance between the tip and ring conductors – Balanced for characteristic AC impedance of 600 Ohms – Provides support for up to four devices per board, uses four time slots, and occupies one card slot in the IGX shelf.
Expanded 1,200-Ohm Line Circuit (MA0209-101/3)	– Provides support for up to eight devices per board, uses eight time slots, and occupies one card slot in the IGX shelf – Otherwise this board is identical to MA0209-102.
1,900-Ohm Line Circuit (MA0317)	– Used for circuits that have up to 1,900-Ohm round-trip DC resistance between the tip and ring conductors – Balanced for characteristic AC impedance of either 900 Ohms or 600 Ohms – Provides support for up to four devices per board, uses four time slots, and occupies one card slot in the IGX shelf.
Dynamic Line Circuit	– Microprocessor-controlled circuit board with up to 16 field-replaceable line circuit modules – Provides support for up to 16 devices per board, uses 1–16 time slots, and occupies 2 card slots in the IGX shelf.

Attendant Console (ATN) Board—Console equipment, such as attendant consoles, personal computer (PC) based video attendant consoles, or dispatch consoles, is connected to the IGX switch using an ATN board. The ATN board is available in two-wire or four-wire configurations for attendant consoles and dispatch consoles, respectively. Each ATN board supports one console, uses one time slot, and occupies one board slot in the IGX shelf. More detailed information on the Redcom consoles is located in Section 4 of this report, as well as in the following manufacturer's manuals:

Attendant Console Feature Addendum (Redcom document 008839)
Video Attendant User's Manual (Redcom document 008050)
Dispatch Console Feature Addendum (Redcom Document 008840).

ISDN Basic Rate Interface (ISDN-BRI) Boards—The Redcom switch can be interfaced to both ISDN-BRI and ISDN Primary Rate Interface (ISDN-PRI) circuits.

ISDN-BRI consists of two 64-kilobit per second (Kbps) bearer (B)-channels, and one 16-Kbps data (D)-channel for a total capacity of 144 Kbps. ISDN-PRI circuits are intended for users with greater capacity requirements. Typically the channel structure for ISDN-PRI is 23 B-channels plus one 64-Kbps D-channel for a total of 1,536 Kbps. ISDN-PRI circuits are covered in depth in Section 2.2.2.3, Digital Trunk Circuit Boards.

ISDN-BRI circuits interface to ISDN terminal equipment through either a U-interface or S-interface. In the United States, the telephone company typically provides its BRI customers with a U-interface. The U-interface is a two-wire (single pair) interface from the telephone switch. It supports full-duplex data transfer over a single pair of wires; therefore only a single device can be connected to a U-interface. This device is called a network termination-1 (NT-1). If, however, the telephone company supplies the NT-1, the customer receives an S-interface. The NT-1 is a relatively simple device that converts the two-wire U-interface into the four-wire S-interface. ISDN terminal devices most commonly use either a U-interface connection (these have a built-in NT-1 device), or an S-interface connection. Devices that connect to the S- or U-interface include ISDN-capable telephones, facsimile machines, video teleconferencing equipment, bridges and routers, and terminal adapters.

ISDN-BRI boards for the IGX switch are available in either U- or S-interfaces. The S-interface board is a four-wire interface, and supports two ISDN sets per circuit. The U-interface board is two-wire interface and supports one ISDN set per circuit. Table 6 includes a brief description of each of these boards.

Table 6
ISDN-BRI Circuit Board Descriptions

Board Name	Description
Basic Rate S-Interface	– Provides four circuits that use a 2B+D format – Assigns a time slot to each of the two bearer channels for each of the four BRI-S circuits – Can support eight ISDN S-interface devices – Uses a total of eight time slots and occupies one card slot in the IGX shelf – Has a master–slave relationship in the IGX switch system. The master provides the timing to the ISDN terminal that is necessary for synchronous communication.
Basic Rate U-Interface	– Provides four circuits that use a 2B+D format – Assigns a time slot to each of the two bearer channels for each of the four BRI-U circuits – Has typical maximum circuit loop length of 18,000 feet of 26 AWG wire – Is a network-side U-interface and supports four ISDN U-interface terminals – Has a master–slave relationship in the IGX switch. The network, as the master, provides the timing necessary for synchronous communications.

3.2.2.2 Analog Trunk Circuit Boards. Analog trunks originating from other switches are connected to the IGX switch using analog trunk circuit boards. An example of this type of circuit is a trunk providing access for long distance telephone calls. The IGX switch supports the following types of analog trunk circuits:

- Ear+mouth (E+M) trunks
- Ground and loop start ring down (GSRD/LSRD) trunks
- Signaling System Five (SS5) trunks
- Single-frequency (SF) trunks
- Two-way loop trunks
- Answering service interface (ASI)
- Cellular access telephone system (CATS) interfaces.

E+M Trunk Board—E+M is an arrangement whereby signaling between a trunk circuit and an associated signaling unit is effected over two leads: an M lead to transmit signals to the signaling unit and an E lead to receive signals from the signaling unit. E+M provides full-time, two-way, two-level supervision. E+M trunk circuits are connected to the IGX switch using E+M trunk circuit boards. While some applications may use physical conductors, in many cases, an intervening transmission method is used, such as a carrier, fiber optics, or microwave. Redcom offers a variety of boards with two-wire or four-wire configurations for direct connection to a variety of equipment. The E+M trunk board contains two circuits, uses two time slots, and occupies one card slot in the switch shelf. Listed in Table 7 are the E+M trunk boards available.

Table 7
E+M Trunk Board Specifications

Interface Type	Type	Impedance	Description
2-Wire	1	600 Ω	Without compandor/squelch control
	1	900 Ω	Without compandor/squelch control
	2	600 Ω	Without compandor/squelch control
	2	900 Ω	Without compandor/squelch control
4-Wire	1	600 Ω	Lossless without compandor/squelch control
	1	600 Ω	Carrier levels without compandor/squelch control
	1	600 Ω	Carrier levels with compandor/squelch control
	2	600 Ω	Lossless without compandor/squelch control
	2	600 Ω	Carrier levels without compandor/squelch control
	2	600 Ω	Carrier levels with compandor/squelch control

GSRD/LSRD Trunk Board—This type of trunk board can be configured either as a GSRD trunk or an LSRD trunk. Each board has two circuits, uses two time slots, and occupies one slot in the IGX shelf. In multiple-shelf configurations these cards are usable from any shelf. Table 8 provides brief descriptions of each of the circuit boards.

Table 8
GSRD/LSRD Trunk Board Description

Board Name	Description
GSRD Trunk	– Used to connect to a ground start line circuit in another switch – Requires that a common ground reference between the IGX and the other switch be present – Allows release of GSRD trunks from either end of the circuit.
LSRD Trunk	– Used to emulate a telephone – Connected to a loop start line circuit in another switch – Places a ringing voltage on the line when another switch places a call to the IGX switch. The LSRD in the IGX switch detects this voltage and routes the call, usually to an attendant. When the attendant answers, the ringing voltage is removed from the circuit and the loop is completed – Can also initiate a loop start call to another switch by coming off hook. The attendant receives a dial tone from the distant switch and can enter digits to place the call.

SS5 Trunk Board—SS5 trunk circuits are connected to the IGX switch using this circuit board. SS5 uses two in-band tones of 2,400 Hz and 2,600 Hz for line signaling. These signaling tones are only present during a change in state of a call. A multifrequency (MF) receiver/sender board is also required for register signaling when using this board. The SS5 trunk board contains two circuits per board, uses two time slots, and occupies one card slot in the IGX switch.

SF Trunk Board—The SF trunk board has two 600-ohm four-wire circuits and a digital signal processor (DSP) to implement in-band signaling. Single-frequency signaling (SFS) is a system that uses a 2,600 Hz in-band signal on the voice path. The tone is on in the idle condition, pulsed for dialing, and off when the circuit is in use. The SF trunk board contains two circuits per board, uses two time slots, and occupies one card slot in the IGX switch.

Two-Way Loop Trunk Board—Two-way loop trunks are connected to the IGX switch using the two-way loop trunk board. This board is used to connect to a comparable circuit in another switching system. In a two-way loop trunk configuration, either end of the circuit can send and receive digits to the other end. This can be performed using either dial pulse (rotary) or DTMF signaling. Each circuit on this board is usable by any shelf within the IGX switch stack. Each board contains two circuits, uses two time slots, and occupies one card slot in the IGX switch.

ASI Board—The ASI is capable of ring down incoming operation or direct-outward-dialing outgoing operation, and is bridged or paralleled across a telephone instrument. Ring down is a circuit or method of signaling in which the incoming signal is actuated by alternating current over the circuit. The circuit can be directly connected as a trunk by omitting the telephone. Each ASI board contains four circuits, uses four time slots, and occupies one card slot in the IGX switch.

CATS Board—The CATS board provides trunk access to the public switched telephone network (PSTN) through an existing cellular network. The CATS board can also serve as a temporary interface in emergency situations or as a wireless trunk for conventional telephone users. The board contains one DB-15 and two RJ-45 connectors for connecting cellular radio transceivers. The CATS board contains two circuits, uses two time slots, and occupies two slots in the IGX switch.

3.2.2.3 Digital Trunk Circuit Boards. Digital trunk circuit boards interface digital trunk circuits to the IGX switch. The switch supports the following digital circuit types:

- T1 direct digital circuits
- T1 with SS5 signaling
- Conference of European PTTs (CEPT-1) circuits
- CEPT-1 with SS5 signaling
- Message transceiver interfaces (MTI)
- Switched 56 Kbps circuits.

T1 Circuit Interface Board—A T1 circuit consist of 24 voice channels digitized at 64,000 bits per second (bps), combined into a single 1.544 megabits per second (Mbps) digital stream (8,000 bps signaling), and carried over 2 pairs of regular copper telephone wires. These circuits can be used for dedicated local access to long distance facilities, long haul private lines, and for regular local service. The Redcom switch has two boards allowing T1 circuit connection. The primary difference between the two is how signaling is accomplished. Outlined in Table 9 are brief descriptions of each of the circuit boards.

Table 9
T1 Interface Boards

Board Name	Description
T1 Direct Digital Interface	– Interfaces the IGX switch to a T1 span line facility – Is a two-board set that typically requires a channel service unit (CSU) for direct connection to the PSTN – Provides 24 voice/data frequency channels – Provides channels 1–12 on the first board and channels 13–24 on the second board – Permits disabling of some channels through the switch database, if all the channels of the T1 interface are not needed. This disabling can be done when it is necessary to conserve time slots – Needs both boards for the interface to operate properly – Has up to 24 circuits, uses 2–24 time slots, and occupies 2 adjacent card slots in the IGX switch.
T1 Interface with SS5 Signaling	– Is only available in international configurations – Occupies 3 car slots within the IGX switch and provides 24 voice/data channels – Is otherwise identical to the T1 direct digital interface board set.

CEPT 1 Circuit Interface—CEPT 1 interfaces are available in international configurations only. The CEPT 1 interface consists of the two circuit boards described in Table 10.

Table 10
CEPT 1 Interface Boards

Board Name	Description
CEPT 1 Interface (MA0337)	– Consists of a transceiver board and a line interface board. » The transceiver board converts the PCM bus stream of the IGX switch into the CEPT 1 format. » The line interface board contains the circuitry for connection to the CEPT line, T1 clock synchronizer board, loop back test circuits, and office alarm relay contacts. – Has up to 32 circuits, uses 2–32 time slots, and occupies 2 board slots in the IGX switch.
CEPT 1 Interface with SS5 Signaling (MA0553)	– Is a three-board set that adds a PCM signaling board to the CEPT 1 interface – Requires all three boards for proper operation.

MTI Board—This board is used when connecting ISDN-PRI circuits to the IGX switch. ISDN-PRI circuits consist of 23 B-channels and one 64 Kbps D-channel. A T1 interface board provides the 23 B-channels in conjunction with the MTI board, which provides the 64-Kbps D-channel. This board will operate at either 56 Kbps or 64 Kbps and can carry on signaling conversations with two external channels. The MTI board contains two circuits, uses two time slots, and occupies one card slot in the IGX switch.

Switched 56 Digital Line Board—The switched 56 digital line board provides an interface between a data service unit/channel service unit (DSU/CSU) and the IGX switch. The circuit board contains two or four circuits per board, uses four time slots, and occupies one card slot in the IGX switch.

3.2.3 Service Circuit Boards

Service circuit boards provide the resources necessary to process and support the internal functions of the switch such as conferencing, system clocking, and tone generation.

Conference Boards—Conference boards are required to conference three or more parties into the same conversation. Two methods of conferencing are employed: “loudest talks” and “additive conferencing.” When loudest talks conferencing is employed, each party on the conference hears the voice of the party with the loudest voice, and the loudest talker hears silence. When additive conferencing is employed, each party hears a voice corresponding to approximately the sum of the voice of the other parties, but not their own voice. Outlined in Table 11 are the four conferencing boards available from Redcom.

Table 11
Conference Boards Description

Board Name	Description
Eight-Party Loudest Talks (MA0018)	– Used for single conference of up to eight parties or two conferences of up to four parties each – Contains eight circuits, uses eight time slots, and occupies one card slot in the IGX switch.
Eight-Party Additive (MA0217)	– Used for single conferences of up to eight parties or two conferences of up to four parties each – Contains eight circuits, uses eight time slots, and occupies one card slot in the IGX switch.
Sixteen-Party Loudest Talks (MA0124)	– Used for single conferences of up to 16 parties – Cannot be subdivided into multiple smaller conferences – Contains 16 circuits, uses 16 time slots, and occupies 1 card slot in the IGX switch.
High-Capacity DSP (MA0609)	– Is programmable to be additive or loudest talks conferencing – Allows conferences of up to 32 parties, or 2 conferences of 16 parties, or 4 conferences of 8 parties – Permits daughter boards to be added to provide an additional 32 party conference capability – Contains eight circuits, uses 2–64 time slots, and occupies one card slot in the IGX switch.

PCM Clocking Boards—The IGX switch uses a PCM scheme to convert analog data and audio into a digital equivalent. The MSU controller board generates the PCM clocking signal. In theory, each shelf should clock itself. However, when multiple shelves are interconnected, the differences between clocking sources could lead to an inability to exchange PCM samples between the shelves. The IGX switch alleviates this problem by using the clock source from only the lowest numbered shelf. The remaining shelves' clocks become backups to the primary clock source. If the primary clock source fails, then the system automatically changes to the clock of the next highest shelf, until it finds a functioning clock source.

System clocking is not an issue when only analog circuits are connected. However, digital circuits create a potential clocking problem because they may exchange clocking signals with the switch. The difference between the outside clocking source (digital circuit) and the internal source (MSU controller) must be eliminated. Table 12 outlines the three clock synchronizer boards offered by Redcom.

Table 12
Clock Synchronizer Board

Board Name	Description
T1 Clock Synchronizer Board	– Locks the IGX clocking source to an incoming 1.544 MHz signal provided on a T1/E1 digital signal – Terminates the output on the front and is connected to the back plane of the lowest numbered shelf in the IGX stack – Can be installed in any of the switch shelves, but must be installed into the slot to the right of the T1 interface card – Permits multiple T1 clock synchronizer boards to be plugged into the IGX switch, but only one clock is used. The remaining clocks become backup clocks – Uses no time slots and occupies one card slot in the IGX switch.
Master Clock Synchronizer Board	– Interfaces the switch to an external reference source – Has two connectors, one that plugs into other clock synchronizers and a second that plugs into the back plane of the IGX shelf – Can be plugged into any of the general-purpose slots of the IGX shelf.
Universal Clock Synchronizer Board	– Provides the functionality of both the T1 clock synchronizer board and the master clock synchronizer board – Provided in one of the following configurations: » Universal Clock Synchronizer—Provides system clock by using an adjacent T1/E1 circuit, external clock source, or clock extractor as a reference signal. » E1/T1 Clock Synchronizer—Provides system clock by using adjacent T1/E1 circuit as reference signal » Clock Extractor—Provides a secondary reference signal using a T1/E1 circuit as a reference. » Clock Source—Provides system clock from a highly accurate internal clock source – Must be installed next to the T1 or CEPT 1 interface except when being used with an external clock reference source.

DTMF Receiver/Sender Board—The DTMF receiver/sender board enables the IGX switch to receive and send digits in DTMF format. Redcom offers two of these types of boards. Each is described Table 13.

Table 13
DTMF Receiver/Sender Board

Board Name	Description
DTMF Receiver/Sender	– Is shared across all trunks – Contains two DTMF receivers and two DTMF senders – Uses two time slots and occupies one card slot in the IGX switch.
DTMF Receiver	– Does not support sending DTMF digits – Is otherwise functionally the same as the DTMF receiver/sender board.

MF Receiver/Sender Board—The MF receiver/sender board enables the IGX switch to send and receive digits in the toll MF format. This board is available in two configurations. Each is described in Table 14.

Table 14
MF Receiver/Sender Board

Board Name	Description
MF Receiver/Sender	– Is shared across all the trunks – Has two MF receivers plus two senders – Uses two time slots, and occupies one card slot in the IGX switch.
MF Sender	– Does not support receiving MF digits – Used to provide Automatic Number Identification (ANI) to central office equipment connected to the IGX – Is otherwise functionally the same as the MF Receiver/Sender board.

Digital Recorded Announcer Board—The digital recorded announcer board is used to supply messages that do not change frequently. This board is offered as a Type 1 or Type 2 board, and contains two circuits. The total record time is 32 seconds, which can be divided up between the circuits as needed. This board uses two time slots and occupies one card slot in the IGX switch.

DSP Board—The DSP board is a multipurpose board that can contain one or two daughter boards, depending on the application. The IGX switch currently supports two DSP functions: caller ID and high-capacity conference calling. The high capacity conference-calling feature allows each DSP board to support up to 32 parties in a conference call. If higher capacity conference call ability is required, additional DSP cards can be installed into the switch. To support caller ID functions, the IGX switch must be equipped with a DSP card to provide caller identification information to the premises equipment. The DSP board contains 8 circuits, uses 2–64 time slots, and occupies one card slot in the IGX switch.

Universal Sensor/Driver (USD) Board—The USD board allows limited control and monitoring of a remote switch site. Each USD board contains eight sensor circuits and eight driver circuits, and must be located in the shelf of the circuit it serves. This board uses no time slots and occupies one card slot in the IGX switch.

MSU to Computer Interface (MCI) Board—The MCI board provides an RS-232 interface between the IGX switch and Data Terminal Equipment (DTE). Each board contains two-circuits. Each circuit is connected to a 25-pin connector located on the front of the board. The upper and lower connectors are designated as circuit 0 and circuit 1, respectively.

4. ATTENDANT AND DISPATCH CONSOLES

Redcom offers two types of console interfaces: attendant consoles and dispatch consoles. An attendant or dispatch console is appropriate for use in environments in which a large volume of traffic must be supported. Where limited control of the IGX switch is needed, a station instrument can be used instead of a console.

4.1 Attendant Console

The attendant console is a compact desk unit that can be installed in an office environment. It is interfaced to the switch using a two-wire ATN board. As needed, the system can be configured with multiple attendant consoles. A data sheet on the attendant console is shown in Appendix A.

4.2 Dispatch Consoles

Redcom's dispatch console performs all the same operations as an attendant console, as well as supporting key/light-emitting diode (LED) per circuit operation. This feature allows console keys and LEDs to be assigned to individual radio channels and conferences as needed for the application. The four-wire ATN board is used to interface dispatch consoles to the IGX switch. Dispatch consoles can be divided into the following categories:

- **Video Attendant Consoles—**Video attendant consoles use a PC-based software package that operates as a Redcom dispatch console. Any standard telephone or headset can be attached for answering calls. Appendix A contains a data sheet on the video attendant console.

- **Non-Modular Fold-Down Dispatch Console—**The non-modular fold-down dispatch console is meant to be used when the switch is mounted into a transportable case. Figure 3 illustrates this console as implemented in Redcom Transportable Communications Package (TCP).

Figure 3
Non-Modular Fold-Down Dispatch Console

When this console is not in use, it is stored in the transportable case. The console contains 160 direct access keys, three 16-character alphanumeric displays, and a DTMF keypad for manual dialing. The 160 direct access keys are programmable for the application, and each key contains 2 LEDs. One LED is green and indicates a conference is in progress. The second LED is red provides call status. The console features a built-in speaker and a jack for connecting an external speaker.

- **Modular Dispatch Console—**Redcom modular dispatch consoles are flexible and can be configured as needed for the application. The console can be as small as a desktop unit or as large as a freestanding 19-inch rack arrangement. Modular consoles are available in the following three sizes:

  – Small Table—12 positions
  – Medium Table—16 positions
  – Large Table—24 positions.

  Modular console sizes can be doubled when needed, resulting in 24-, 32-, or 48-position console capability. Modular consoles are assembled from the selection of required console modules described in Table 15.

Table 15
Console Modules (Required)

Module Name	Description
Control Module	– Controls the console and communicates with the MSU.
Transmission Module	– Interfaces to the four-wire handset – Features a speaker that chimes to announce an incoming call.
Keypad Module	– Provides the keys and LEDs required to aid the attendant in handling calls.
Display Module	– Provides displays and LEDs to aid the attendant in handling calls.

As special functions are needed, additional, optional console modules can be added. Table 16 describes these optional console modules.

Table 16
Console Modules (Optional)

Module Name	Description
Console Speaker Module	– Provides audio monitoring of all circuits in conversational mode with the attendant – Is not available for the small table console.
Line/Trunk Access Module	– Contains eight user-programmable keys to allow direct access to lines, trunks, radios, recorders, conference, and attendants.
Special Keypad Module	– Functions the same as the line/trunk access module – Is not available for the small table console.
Radio Speaker Module	– Serves as the audio interface to user-supplied radios – Is not available for the small table console.
Power Supply Module	– Supplies power to the console.
Alarm Speaker Module	– Serves as the alarm interface dedicated to a specific incoming line circuit – Is not available for the small or medium table consoles.

5. Switch Configurations

5.1 Introduction

Redcom develops IGX switch systems for the customer's application. Each switch deployed can be designed in a custom fashion to support unique agency requirements. Presented in this section are several of the more common configurations typically desired by public safety-type agencies. Since unit costs are tied so closely to the customer's desired features and capabilities, a generic cost summary for each configuration is not provided. Rather, sample costs are shown for a generic switch, configured with sufficient capacity to accommodate incident commanders and key support personnel responding to a medium-size incident. This cost, shown in Section 5.2, is intended to provide readers with a sense of the general cost an agency might expect when considering implementing the IGX solution.

5.2 Sample Configuration

The PSWN Program developed a sample configuration for this report that could provide interoperability communications for a small-scale operation. The specifications of the sample system are listed in Table 17.

Table 17
Sample Configuration

Specification	Qty.
Radio Ports	4
Analog Subscriber Unit Ports	24
Trunk Circuits	2

The generic configuration would be mounted into a 19-inch rack-mount transit case. In this case, up to four radios would be interfaced to the switch using one RLI card. Conferencing circuits would be used to patch radios together for communications interoperability. The 24 analog subscribers could be used to interface telephone instruments, facsimile machines, modems, etc., to the switch. The two trunk circuits provide incoming and outgoing calling capability to telephone and radio subscribers connected to the switch. Pre-planning and coordination is critical in determining how such a system would be configured. The cost of this package would be approximately $22,000.

5.3 Redcom Switching Applications Overview

The IGX switch is available from Redcom in both integrated packages or as equipment-only solutions. One such integrated solution, called the Tactical Communications Package (TCP), is tailored to the requirements of the customer's application. TCP packages may be similar, but the capabilities of each system can be significantly different depending on the cards installed. Section 5.3.2 describes the TCP.

The IGX switch is also available in integrated packages developed by other manufacturers. This report presents an overview of one such application, the Ready Set system, built by Motorola, which is similar to Redcom's TCP. Section 5.3.3 introduces Ready Set.

The third application presented in Section 5.3.4, is a fixed installation in a vehicle. This system, engineered by New York State Enterprise Corporation (NYSTEC), is called the Deployable Advanced Communications Environment (DACE).

Where applicable, manufacturer data sheets are included in Appendix B.

5.3.1 Operational User Feedback

The PSWN Program created an interview guide to gather anecdotal information from public safety agencies with operational deployments of a Redcom switch solution.

System Information

One federal agency installed the Redcom switch (IGX-C) configured with the following circuits:

MSU 0—Card Cage

Circuit Name	Circuit Abbreviation	Number of Slots Used
MSU Controller	MSU	2
Expanded Timeslot Interchange	ETSI	2
Ringing Generator	LIN	1
T1 Interface	DS1	2
Digital Signal Processor	DSP	1
Ringing Generator	RNG	1
Clock Synchronizer	SYN	1

MSU 1—Card Cage

Circuit Name	Circuit Abbreviation	Number of Slots Used
MSU Controller	MSU	2
Expanded Timeslot Interchange	ETSI	2
Radio Line Circuit	RLC	1
T1 Interface	DS1	2
Clock Synchronizer	SYN	1
Digital Signal Processor	DSP	1
Ringing Generator	RNG	1

MSU 2—Card Cage

Circuit Name	Circuit Abbreviation	Number of Slots Used
MSU Controller	MSU	1
Expanded Timeslot Interchange	ETSI	2
Ringing Generator	RNG	1
Digital Signal Processor	DSP	1
Digital Signal Processor	DSP	1
T1 Interface	DS1	2
1,200 Ohm Line Circuit	Line	1

MSU 3—Card Cage

Circuit Name	Circuit Abbreviation	Number of Slots Used
MSU Controller	MSU	2
Expanded Timeslot Interchange	ETSI	2
1,200 Ohm Line Circuit	LIN	1
T1 Interface	DS1	1
Attendant Console	ANN	1
Digital Signal Processor	DSP	2
Ringing Generator	RNG	1

This specific agency used the circuits outlined above to provide connectivity and achieve interoperability between local, state, and federal law enforcement agencies. In this configuration, four T1 lines were used to interface the Redcom switch to Verizon's cellular network. The agencies operating throughout Verizon's coverage area and within the Washington Metropolitan Area Transit System (WMATS) were capable of conferencing with each other through the Redcom switch.

To test the conferencing capabilities of the Redcom switch, a test conference was set up using the ETSI card, that connected a VHF radio, PBX telephone, three telephones located in different regions of the country, and three cellular telephones. The three operating regions were the Washington, DC, subway system, Quantico, and in Pennsylvania. The test configuration was pre-programmed into the Redcom switch using specific ports, which were connected to the landline telephones, cellular network, and radios in the three regions. Further, a single initiator code was used with this configuration. The conference ports could not be connected to each other until the initiator code has been sent. Once this occurred, each user could call into the switch using the predefined telephone number, enter his or her access code, and join the conference. This application was limited to 8 conference ports for testing purposes; however, the Redcom switch can handle 96 total conference ports. During testing of this specific configuration, eight callers successfully connected to the conference. When a ninth caller attempted to dial-in and join the conference, the caller received a busy tone from the switch.

According to the testers, all parties connected on the test conference call received a good quality connection and stated that the voice transmissions were noticeably clear. Typically, in configurations interfacing disparate radio systems, the audio quality of the conference is degraded due to the different vocoder technologies used.

Operational Feedback

For this particular application, the Redcom switch was chosen based on its extensive conferencing capabilities and high reliability. Redcom was not the only switch vendor considered for this application. Nortel Networks and JPS Communications were two other switch manufacturers considered during the procurement process but were not selected because of cost and operational considerations.

During the installation and optimization of the Redcom switch, no internal hardware problems were encountered. However, testers reported that there were two significant issues requiring resolution —

- Setting up T1 lines to an operational state
- Conferencing failure with the switch's internal firmware.

The T1 lines used in this application were not operational at the time of installation. Once the T1 lines were repaired, the switch had connectivity to Verizon's Mobile Telephone Switching Office (MTSO).

The switch's internal firmware caused a problem with the conferencing capabilities. During a typical conference call, each user calls into the switch, enters an access code to the switch, enters the conference call access code, and joins the conference. Once eight users have joined the eight-party conference call, no other users can join. If another user attempts to join the eight-party conference call, that user will receive a busy tone at his or her receiver. During the eight-party conference test, the conference initiator disconnected from the active conference call. This left seven users active in the conference. When the initiator attempted to rejoin the conference as the eighth caller, a busy tone was incorrectly received . The issue was relayed to Redcom representatives, and they resolved the problem, which was found in the firmware. The eight-party conference call was tested as before, and no further problems were encountered with the firmware.

A dialing plan is required for any multiparty conference configuration on a Redcom switch. This plan is developed based on the specific application of the switch. In this case, the dialing plan was for an eight-party conference. The dialing plan defines the conference bridge number and specifies the parties that can be granted access to the bridge number.

Generally, the development of a dialing plan is complex, requiring an experienced user to construct it. Redcom offers a service to develop dialing plans for particular switch applications. In this case, the agency asked Redcom to develop the dialing plan; however, because of concerns about confidentiality, only a high-level outline of the desired uses for the switch was provided to

Redcom. Ideally, Redcom would be given detailed information regarding the switch application so that a dialing plan could be developed accordingly.

System Training and Documentation

Training was required for this particular application of the Redcom switch. Members of the agency's staff attended a 2-week training course that included instructions on how dialing plans were developed and programmed into the Redcom switch. Upon completion of the training course, the agency personnel could add the level of detail required for their specific applications. During the training, Redcom provided each attendee with a full documentation package as reference material for hands-on activities. According to the customer agency, the Redcom switch functioned well and met all of the requirements for their particular application.

Additional User Feedback

Additional user feedback was requested from another entity using the Redcom switch. Unlike the application presented above, in which feedback was obtained through a live interview along with an interview guide, feedback for this additional Redcom switch application was obtained using only an interview guide. Given the limited information obtained in this second application, no additional lessons learned were discovered.

The interview guides are shown in Appendix C and the results from agency interviews are shown in Appendix D.

5.3.2 Redcom Tactical Communications Package

Redcom's TCP, as illustrated in Figure 4, is a fully integrated communications system. The system is built into a stackable, 19-inch rack mount transit case, and is designed around an RJ-45 based quick-connect system that allows rapid configuration (or reconfiguration) in the field to meet changing needs.

Figure 4
Redcom Tactical Communications Package

TCP pricing varies depending on the configuration. Further information on the TCP application can be obtained directly from the manufacturer:

Redcom Laboratories, Inc.
One Redcom Center
Victor, New York 14564-0995
(716) 924-6500
Web Site: www.redcom.com

5.3.3 General Dynamics (formerly Motorola) Ready Set

The Motorola Ready Set, as illustrated in Figure 5, has, as one of its main components, a Redcom IGX switch. The IGX switch is used to integrate telephone, digital imagery, data, two-way radio, cellular, and paging services. Additional information on the Ready Set can be found. at www.generaldynamics.com.

Figure 5
General Dynamics Ready Set

5.3.4 Deployable Advanced Communications Environment

NYSTEC has developed a mobile communications package called DACE, which is illustrated in Figure 6. The DACE incorporates a Redcom IGX switch that interconnects the telephone networks, public safety band radios, data networks, and cellular networks.

Figure 6
Deployable Advanced Communications Environment

For further information on the DACE and the NYSTEC program, refer to the information below:

NYSTEC
75 Electronic Pkwy
Rome, NY 13441
Phone (315) 338-5818
E-mail Address nystec@nystec.com
Web Site: www.nystec.com

APPENDIX A—REDCOM CONSOLE DATA SHEETS

Current, up-to-date Redcom console datasheets can be found on the Redcom WebPages at www.redcom.com. The console datasheets used in this assessment were current as of the time of this document (July 2002).

APPENDIX B—APPLICATION DATA SHEETS

Current, up-to-date Redcom application datasheets can be found on the Redcom WebPages at www.redcom.com. The application datasheets used in this assessment were current as of the time of this document (July 2002).

APPENDIX C—INTERVIEW GUIDE

APPENDIX D—INTERVIEW GUIDE RESULTS

The information provided in the competed surveys is proprietary and sensitive in nature. To protect the integrity of the systems that were studied in this assessment, the completed surveys will not be made available to the public.

APPENDIX E—ACRONYMS

AC	Alternating Current
ANI	Automatic Number Identification
ASI	Answering Service Interface
ATN	Attendant Console
AWG	American Wire Gauge
B	Bearer
BRI	Basic Rate Interface
BTU	British Thermal Unit
C-AT	Communications-Applied Technology (company)
CATS	Cellular Access Telephone System
CODEC	Coder/Decoder
CEPT	Conference of European PTTs
COR	Carrier Operated Relay
CSU	Channel Service Unit
D	Data
D	Depth
DACE	Deployable Advanced Communications Environment
Db	Decibel
DC	Direct Current
DCFD	District of Columbia Fire Department
DSU	Data Service Unit
DSP	Digital Signal Processor
DT	Dual Tone
DTE	Data Terminal Equipment
DTMF	Dual Tone Multi Frequency
E	Ear
E+M	Ear and Mouth
EIA	Electronics Industry Association
EMS	Emergency Medical Services
ETSI	Expanded Time Slot Interchange
GSRD	Ground Start Ring Down
H	Height
HF	High Frequency
Hz	Hertz
ICRI	Incident Commanders Response Interface
IGX	ISDN Gateway Exchange
ISDN	Integrated Services Digital Network
JCIT	Joint Combat Information Terminal
K	Kilo
Kbps	Kilobits per second
LED	Light Emitting Diode
LSRD	Loop Start Ring Down
M	Mouth
Mbps	Megabits per second
MCI	MSU to Computer Interface

MF	Multifrequency
MHz	Megahertz
MSU	Modular Switching Unit
MTI	Message Transceiver Interface
NT	Network Termination
NYSTEC	New York State Technology Enterprise Corporation
PBX	Private Branch Exchange
PC	Personal Computer
PCM	Pulse Code Modulation
PRI	Primary Rate Interface
PSWN	Public Safety Wireless Network
PSTN	Public Switched Telephone Network
PTT	Push-to-Talk
RLI	Radio Line Interface
RMS	Root Mean Square
SF	Single Frequency
SFS	Single-Frequency Signaling
SS5	Systems Signaling Five
TCS	Transportable Communications System
TCP	Tactical Communications Package
USD	Universal Sensor/Driver
TPSRIU	Transportable Public Safety Radio Interoperability Unit
V	Volt
VHF	Very High Frequency
VOX	Voice Operated Transmit
Vrms	Volts Root Mean Square
W	Width
WITS	Wireless Interface Telephone System